

T H E
A R T
O F M A K I N G
C O M M O N S A L T,

As now Practised in
Most Parts of the World;

W I T H S E V E R A L
I M P R O V E M E N T S

PROPOSED in that A R T,
For the USE of the
BRITISH DOMINIONS.

B Y
WILLIAM BROWNRIGG, M.D.F.R.S.

L O ³⁹ N ²⁶⁷ D / O N,

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PREFACE.

IT is an old remark, that *all arts and sciences have a mutual dependance upon each other*. The philosopher borrows many experiments from the mechanic, which assist him in his searches into nature ; the mechanic avails himself of the discoveries of the philosopher, and applies them to the uses of mankind. Thus men, very different in genius and pursuits, become mutually subservi-

ent to each other; and a very useful kind of commerce is established, by which the old arts are improved, and new ones daily invented, and the knowledge of nature is continually advanced, and brought nearer to perfection. Those trades therefore and occupations of life, which formerly brought honour to their inventors, ought not now to be treated with contempt, because grown vulgar and common; but rather, for their general usefulness, should be held in the greater esteem; and in a particular manner they demand the regard of philosophers, who have been taught by the noble Verulam, that *the* history of mechanic arts is a necessary part of that knowledge, upon*

* Verulam *De augment. scient.* Lib. ii. c. 2.

which

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which alone, as on a firm basis, can be built that true science of nature, which is not taken up in vain and fruitless speculations, but effectually labours to relieve the necessities of human life.

AMONGST these vulgar arts, that of making salt, or of preparing and fitting it for the uses of mankind, hath been thought worthy the notice of many great and learned men, as well amongst the antient as moderns. Thus, many things relating to this art are recorded by *Cato*, and *Pliny* the Naturalist. And, if we search the writings of the moderns, we shall find the improvements in this art carefully collected by *George Agricola*, *Frederick Hoffman*, and many other excellent physicians; to which body

of men we are chiefly indebted for those memoirs, that have been transmitted to us, relating to its history. Had those great men been as diligent in improving this art, as they were in recording the improvements made in it by others, there would not now have been occasion to remark, that, after the practice of so many ages, *an art so simple, and withal so necessary, hath not yet been brought to any great degree of perfection.*

THAT this art was capable of great improvements, especially as practised in Britain, was the sentiment of the *Royal Society* soon after its institution; at which time that renowned body was very intent upon bringing it to greater perfection; as may be gathered

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ed from the inquiries and suggestions of Dr. Beal, and the histories of several methods of making salt, which then were published by that Society. And although the English have, since that time, considerably improved their methods of boiling salt; yet *this art is still practised with greater skill and success by their allies the Dutch*; as the superior goodness of the fish, cured with their salt, doth sufficiently prove.

THAT august body *the Commons of Great Britain*, having therefore taken into consideration the great importance of this art, judged some improvements proposed therein worthy of its regard and encouragement; well knowing, that *could this be brought to*
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x P R E F A C E.

the same perfection in Britain, as in some neighbouring countries, large sums of money might be saved in the nation, which are now annually paid to the French and other foreigners; its fisheries might be greatly improved; and its navies and commerce, and many of its richest colonies would no longer depend upon its enemies for one of those necessaries, without which they cannot be supported.

THESE considerations have induced me to give a brief account of the various methods of making salt which now are used in Great Britain, and in other countries where this art is practised with more success; and also to attempt several further improvements in this art for the
use

use of the British dominions. How far I have succeeded in these attempts will best appear, if the public shall think the following proposals so far worthy of their attention as to merit a fair and impartial trial. The principal conclusions, deduced from a variety of observations and experiments, are as follows. First, *That by the methods here proposed, an excellent bay salt may be made in Britain, in very large quantities, so as to be afforded cheaper than at the prices paid for foreign salt; and that the British colonies in America may very commodiously be supplied with bay salt of their own manufacture, without having recourse for it to the French, Spaniards, and Portuguese.* Secondly, *That, by the methods here proposed, an excellent kind of refined*
white

white salt may be made in Britain, as well from sea water, and rock salt, as from natural brine, in any quantity wanted, so as to be afforded cheaper than foreign bay salt; and which will also be better than common bay salt for curing fish, flesh, and other provisions.

IN forming these conclusions, I have had an impartial regard to truth, and to the utility of the public, without attending to the private advantages of any particular set of men. Some things perhaps may here be offered which have escaped the notice of others. The sense of this, together with a desire of promoting the public advantage, have induced me to communicate the following sheets. And I
rather

rather chose, at this time, to submit them to the candour of the reader, defective as they are, than by deferring the publication with a view of making them more accurate, to let slip the present occasion ; which indeed seemed the most favourable for attempts of this kind, as the nation is at present engaged in war with several potent enemies, from whom it hath heretofore been chiefly supplied with this commodity. And more especially as by the late acquisition of *Cape Breton*, an opportunity is offered of extending the *British fisheries*, towards which there seems a laudable zeal in the nation ; wherein an opinion hath also prevailed, that *the establishing of fisheries in the North of Scotland* would be the best means of
affording

affording an useful employment to the more uncivilized inhabitants of that part of the kingdom ; for carrying on of which they are most commodiously situated.

WHAT Mr. Lowndes hath lately done towards the improvement of brine salt, may, perhaps, by some, be thought to supersede the necessity of any further attempts *for improving and extending our salt manufacture.* I am very far from desiring to depreciate the endeavours of that gentleman, which have met with parliamentary encouragement ; and had his discoveries appeared to me sufficiently complete and extensive, I should not have given the public and myself this trouble. I make no doubt but that the
specimen

specimen of salt, which he exhibited before the College of Physicians, was *a strong and pure salt*, since such it appeared to that most learned body. Whether the *allum mixed with it* (agreeable to the ancient practice of the Cheshire salt boilers) contributed any thing to its goodness, will be more properly considered in another place. It is only necessary here to observe, in *justification of the present undertaking*, that Mr. Lowndes's method of making salt for curing provisions, doth not appear to be *the best* that may be put in practice ; since I hope to shew, that by other methods *a purer and stronger salt may be made, and at a less expence*. Neither is his method so *general and extensive* as seems to be required
for

for the public good ; since Mr. Lowndes confines it almost entirely to boiled brine salt ; and hath given no directions concerning the preparation of bay salt. He indeed proposes to meliorate the British sea salt, but seems to despair of preparing a salt either from sea water, or the English rock-salt, fit for the uses of the navy or fisheries ; although the Dutch salt, which is the strongest and purest boiled salt now made, is entirely a marine salt, and even the brine, of which Mr. Lowndes makes his salt, is only a solution of the English rock-salt, often in very impure water, as is well known to naturalists.

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INTRODUCTION.

Of SALT in general.

THE salt, which we use as a seasoning to our food, is, of all salts, the most excellent¹, and also the most common. It hath pleased the author of nature to provide mankind with ample stores of this most useful and necessary commodity. There are few countries which do not afford vast quantities of rock or fossil salt.² Mines of it have long been discovered and wrought in England, Spain, Italy, Germany, Hungary, Poland, and other countries of Europe. In several parts of the world, there

¹ The superior excellency of common salt, appears from its extraordinary uses to mankind in their food, its admirable effects upon metals, and many other properties.

² Amongst the salt mines of chief note are those of Northwich in Cheshire, Altomonte in Calabria, Hall in Tyrol, Cardona in Catalonia: also those stupendous mines at Wilizka in Poland, and Soóvár in Upper Hungary; of which see accounts in *Phil. Trans.* N^o. 61 and 413.

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are huge mountains which wholly consist of fossil salt. ³ Of this kind are two mountains in Russia nigh Astracan ; several in the kingdoms of Tunis and Algiers in Africa ; and several also in Asia ; and the whole island of Ormus in the Persian gulph almost entirely consists of fossil salt ⁴. The new world also is stored with treasures of this useful mine-

³ The reverend and learned Dr. Shaw gives us the following account of the salt of some mountains in Algiers. “ Jibbel Had-deffa is an entire mountain of
“ salt, situated near the eastern extremity of the lake
“ of Marks. The salt of it is of a quite different quality
“ and appearance from that of the *salinæ*, being as hard
“ and solid as stone, and of a reddish or purple colour.
“ Yet what is washed down from these precipices by
“ the dews, attaineth another colour, becoming as white
“ as snow, and losing that share of bitterness which
“ is in the parent rock salt. The salt of the mountains
“ near Lwotaiah and Jibbel Miniss is of a grey or
“ blueish colour, and, without submitting to the like
“ accidental purification as at Had-deffa, is very agree-
“ able to the palate ; the first especially, being sold at
“ Algiers for a penny the ounce.” See his *Travels*,
p. 229.

⁴ “ Sunt et montes nativi salis, ut in Indis Oromenus,
“ in qua lapicidinarum modo cæditur, renascens : ma-
“ jusque regum vectigal ex eo est, quam ex auro atque
“ margaritis. Effoditur et e terrâ, ut palam est, hu-
“ more densato, in Cappadocia. Ibi quidem cæditur
“ specularium lapidum modo. Pondus magnum glebis,
“ quas micas vulgus appellat. Carrhis Arabiæ oppido
“ muros domosque massis salis faciunt, aqua ferruminan-
tes.” Ita *Plinius Nat. Hist.* lib. xxxi. c. 7.

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ral, as well as with all other kinds of subterranean productions⁵.

MOREOVER, the sea affords such vast plenty of common salt, that all mankind might thence be supplied with quantities sufficient for their occasions.

THERE are also innumerable springs, ponds, lakes, and rivers, impregnated with common salt, from which the inhabitants of many countries are plentifully supplied therewith.

IN some countries, which are remote from the sea, and have little commerce, and which are not blessed with mines of salt, or salt waters; the necessities of the inhabitants

⁵ “ In these parts [of Peru] is also found great
“ abundance of the mine or rock salt, which is massy
“ and transparent, looking like the purest crystal. Jul-
“ loma hath in it plentiful veins of this kind of salt.
“ Many years ago the inhabitants of Curagnara de Ca-
“ rangas have enriched themselves by digging of rock
“ salt; and of late years they have discovered veins of
“ it near the river of Langacollo. But the salt mines
“ of Yocalla, which God hath created near unto the
“ rich mountain and city of Potosi, that nothing might
“ be wanting that was necessary for the working of its
“ ore, yield such abundance of salt as is incredible;
“ whereof is daily spent in the working of metals at the
“ least fifteen hundred quintals, and this consumption
“ hath lasted for many years.” Alonso Barba, *Treatise*
of metals, mines, &c. Chap. vii.

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have forced them to invent a method of extracting their common salt from the ashes of vegetables⁶.

⁶ The muriatic salt of vegetables was described by Dr. Grew under the title of lixiviated marine salt. Leewenhoeck obtained cubical crystals of this salt from a lixivium of soda or kelp, and also from a solution of the lixivial salt of *Cardus benedictus*; of which he hath given figures in a letter to the Royal Society, published in N^o. 173 of their *Transactions*. Dr. Dagner, in *Act. Acad. N. C.* vol. v. obs. 150. takes notice of great quantities of it which he found mixed in pot-ashes. And the ingenious Dr. Fothergill extracted plenty of it from the ashes of fern. See *Medical Essays*, vol. v. article xiii.

The muriatic salt which the excellent Mr. Boyle extracted from sandiver, and supposed to be produced from the materials used in making glass, was doubtless separated from the kelp made use of in that process. See his *Works abbr. by Dr. Shaw*, vol. iii. p. 376. Kunkel also informs us, *Obs. Chem. post.* p. 136. that he took an alkaline salt, and after calcining it with a moderate fire, dissolved it in pure water, and placing the solution in a cool cellar, obtained from it many crystals of a neutral salt. He supposes that the alkaline salt was by the process converted into this neutral salt. But 'tis more reasonable to believe, that the alkaline salt which he applied was not pure, but mixed with the muriatic salt of vegetables, which by this process was only separated from it.

'Tis doubtless chiefly this muriatic salt, which, in some of the inland parts of Asia, they extract from the ashes of duck-weed, and of Adam's fig-tree, and use for their common salt. An obscure description how this salt is made in the kingdom of Asem, may be seen in Monsieur Tavernier's *Voyages*, Part II. book ii. chap. xvii.

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IN short, this salt is dispersed over all nature ; it is treasured up in the bowels of the earth ; it impregnates the ocean ; it descends in rains⁷ ; it fertilizes the soil ; it arises in vegetables ; and from them is con-

That they are able in those countries to make common salt to profit from vegetables, ought not to be wondered at, since I have been assured by a gentleman of great worth, who had the best opportunities of informing himself, that at Dehli and Agra, capitals of Indostan, salt is so scarce as usually to be sold for half a crown a pound. We may therefore give some credit to Marco Polo, when he informs us, that in the inner parts of the same quarter of the world, in the province of Caidu, lying west of Tebeth, the natives used salt instead of money, it being first made up in cakes and sealed with the stamp of their prince ; and that they made great profit of this money by exchanging it with the neighbouring nations for gold and musk. We are also told by Ludolfus, in his *Historia Æthiopica*, that in the country of the Abissines there are mountains of salt, the which when dug out is soft, but soon grows hard ; and that this salt serves them instead of money to buy all things. The same is confirmed by Ramusio. See his *Voyages into Æthiopia*, chap. 39 and 52.

⁷ Mr. Boyle, in his treatise on the saltiness of the sea, takes notice that not only rain water, but also snow water is very frequently impregnated with sea salt. — In a violent storm which happened in November 1703, the rain which fell in several parts of Sussex was strongly impregnated with common salt ; and Mr. Leewenhoek, at Delft in Holland, observed many crystals of that salt left by the rain, which dashed against his windows during the said storm. *Ph. Transf.* N°. 289. p. 1530—35.

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veyed into animals⁸. So that it may well be esteemed the universal condiment of nature ; friendly and beneficent to all creatures endowed with life, whether it be vegetative, or animal.

NATURALISTS, therefore, observing the great variety of forms under which this salt appears, have thought fit to rank the seve-

⁸ Mr. Boyle discovered common salt in human blood and urine. I have observed it, not only in human urine, but also in that of dogs, horses, and black cattle. It may easily be discovered in these, and many other liquids impregnated with it, by certain very regular and beautiful starry figures which appear in their surfaces after congelation. These figures I first observed in the great frost in the year 1739, and may probably have occasion to give a fuller account of them elsewhere.

The dung of such animals as feed upon grass or grain, doth also contain plenty of common salt ; as appears from the method of preparing sal ammoniacum in Egypt. This salt, as 'tis well known, is composed of a volatile alcali, saturated with spirit of common salt, and is there sublimed from soot. Now as the dung of camels, asses, and black cattle is the common fuel of Egypt ; whilst it is burning, the fire separates from it a volatile alkaline salt, and also the acid fumes of common salt ; these uniting together in the soot form a sal ammoniacum, which is afterwards separated from it by sublimation.

From this process we also learn, that when vegetables are calcined (at least such of them as have undergone putrefaction) all their muriatic salt doth not remain in their ashes ; but a considerable portion of it is separated into its principles of an acid spirit and a fixed alkaline earth.

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ral kinds of it under certain general classes; distinguishing it, most usually, into rock or fossil salt, sea salt, and brine or fountain salt. To which classes, others might be added of those muriatic salts which are found in vegetable and animal substances.

THESE several kinds of common salt often differ from each other in their outward form and appearance, or in such accidental properties as they derive from the heterogeneous substances with which they are mixed. But when perfectly pure, they have all the same qualities; so that chemists, by the exactest inquiries, have not been able to discover any essential difference between them⁹.

⁹ “ Ut igitur nostra hac de re innotescat sententia,
 “ hanc interponimus: sicuti in totâ universi hujus com-
 “ page, una tantum est aqua, unus per fermentationem
 “ paratus spiritus ardens, unus mercurius, unum volatile
 “ sal, unum acidum nitrosum ac vitriolicum sal; ita,
 “ pari ratione unum idemque sal commune est: sed
 “ quum plures alienæ, terreæ, lapidosæ, sulphureæ, cal-
 “ carix minerales ac pingues particulæ cum hisce cor-
 “ poribus connubium ineant, diversa exinde emergit
 “ eorum indoles; et sal commune idem semper obti-
 “ neret ingenium, si quis pingues, terreas, calcareasque
 “ partes ab illo artificiosè segregare nosset.” Hoffman
De salinis Hallens. cap. viii.

Dr. Lister indeed (in his treatise *De font. Med. Angliæ*, L. i. c. i. § iii.) takes notice that the crystals of sea salt differ somewhat in figure from those of fountain and fossil salt; and seems to think this a great discovery.

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LEAVING therefore these divisions to those whom they may concern ; it will, for our present purpose, be more proper to distinguish common salt after a different manner, into the three following kinds, viz. into rock or native salt, bay salt, and white salt.

By rock salt, or native salt, is understood all salt dug out of the earth, which hath not undergone any artificial preparation.

UNDER the title of bay salt may be ranked all kinds of common salt extracted from the water wherein it is dissolved by means of the sun's heat, and the operation of the air. Whether the water, from which it is extracted, be sea water, or natural brine drawn from wells and springs, or salt water stagnating in ponds and lakes.

UNDER the title of white salt, or boiled salt, may be included all kinds of common salt extracted by coction from the water wherein it is dissolved ; whether this water be sea water, or the salt water of wells, fountains, lakes, or rivers ; or water of any sort impregnated with rock salt, or other kinds of common salt ¹⁰.

Bnt others assert that this difference is only accidental and not constant ; proceeding from some particular circumstances attending the crystallization.

¹⁰ The following relations extracted from Alonso Bar-

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THE first of these kinds of salt is in several countries found so pure, that it serves for most domestic uses, without any previous preparation (triture excepted.) But the English fossil salt is unfit for the uses of the kitchen, until, by solution and coction it is freed from several impurities, and reduced into white salt. The British white salt also is not so proper as several kinds of bay salt for curing fish, and such flesh meats as are intended for sea provisions, or for exportation into hot countries. So that for these purposes we are obliged, either wholly or in part, to use bay salt, which we purchase

ba seem very particular. “ In the Lipes—there is a small
 “ lake upon the top of a little hill—in the middle of
 “ which lake the water boils and leaps up, sometimes
 “ more, sometimes less; making a frightful noise. Out
 “ of curiosity I went to see it, and found the noise and
 “ motion of it so terrible, that with reason there be
 “ very few that dare come near the mouth of it. The
 “ water is thick to that degree, that it looks more like
 “ dirt than water. There is one small gutter where it
 “ runs over; and the water that issueth forth becomes
 “ red salt as it runs along in little channels. This
 “ is a mighty strong salt, and has twice the virtue of
 “ common salt in the working of metals. It hath also
 “ been found to be an excellent remedy for the dysen-
 “ tery; perchance it hath in it a mixture of the red
 “ alum that gives it both colour and spirit. Hard by
 “ this lake runs a vein of Piedra Judaica, and the
 “ country thereabouts is full of mines of copper.”

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in France, Spain, and other foreign countries.

THE following sheets were wrote with a design to remove these inconveniences, by shewing how the subjects of Great Britain may be supplied with salt of their own manufacture, fit and sufficient for all their occasions. But in order that the methods here proposed may be better understood, and that the reasonableness of them may more fully appear, it will be necessary to premise a brief account of the several ways of preparing bay salt as well as white salt, so far

“ A league and a half from Julloma, in the province
“ of Pacages, there be many salt springs that, as they
“ gush out of the ground, in a short time become pure
“ white salt, without the help of any art; and they
“ increase into heaps of salt until the winter rains dis-
“ solve and sweep them away.” N. B. This last account is confirmed by Herrera.

’Twould be difficult to determine to which of the classes here mentioned those two kinds of salt belong. It being uncertain, from the description, whether they are fossil salts, or salts boiled by subterranean heat, or, lastly, salts coagulated by the heat of the sun. The first kind is a very impure salt, seeming to contain a large quantity of ferruginous earth, and probably also a mineral alcali, as may be conjectured from its effects upon metals. It seems to be emitted from a fiery spiracle, much resembling that called La Salsa in the territory of Modena; which, Ramazzini informs us, continually boils with melted bitumen.

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as they are come to our knowledge. For from this history we may form a judgment how far the methods now in use are proper, in what deficient, and where erroneous, and how they may be improved. The same history will also contain many observations and experiments which are required in demonstrating the propositions in the third and fourth parts of this treatise.

PART

P A R T I.

The A R T of preparing
B A Y S A L T.

C H A P. I.

Of B A Y S A L T in general.

I N relating what I have been able to collect concerning the several ways of making salt, which now are, or formerly have been in use, order requires that the more simple methods should first be described, and afterwards those which are more artificial and compounded. It will therefore be proper, in the first place, to relate the several methods of preparing bay salt, so far as they have come to our notice; and where the subject will admit of it, I shall draw examples

ples from the practice of those who are employed in preparing that commodity for the use of the British dominions.

BAY salt may be divided in general into two kinds. First, bay salt drawn from sea water ; as is practised in France, Spain, Portugal, and many other countries. Secondly, bay salt extracted from salt springs, ponds, and lakes ; as at the Cape de Verd islands, in Africa ; and at Salt-Tortuga, Turks Island, and many other parts of America.

THE first kind is imported, in large quantities, into Great Britain and Ireland ; and our American colonies, and fisheries, in times of peace, are chiefly supplied with the latter ; but now in time of war, they have large quantities of bay salt from Lisbon, and other parts of Portugal.

C H A P. II.

Of bay salt extracted by a total exhalation of the water wherein it was dissolved.

BAY salt is prepared in a manner the most simple and easy, when the water of ponds and lakes impregnated with salt is totally exhaled, by the force of the sun
2 and

and air, and the salt is left concreted into a hard crust, at the bottom of the lake or pond.

OF salt thus prepared we have many instances in several parts of the world ¹. Thus,
 “ In the Podelian desert near the river Bo-
 “ rysthenes is a salt lake, whose water, by
 “ the heat of the sun, is wasted, and turn-
 “ ed to salt, like unto ice; so that the
 “ people ride into it with horses and wag-
 “ gons, and cut it into pieces, and carry it
 “ away ².” I was also informed by a
 worthy friend ³, who long served as a phy-
 sician in the Russian armies, that in the
 same part of the world, viz. on the Rus-
 sian frontiers towards Crim Tartary, he had,

¹ “ Siccatur in lacu Tarentino æstivis solibus, to-
 “ tumque stagnum in salem abit, modicum alioquin,
 “ altitudine genua non excedens. Item in Sicilia in
 “ lacu, qui Conanicus vocatur, et alio juxta Gelam.
 “ Horum extremitates tantum inarescunt; sicut in
 “ Phrygia, Cappadocia, Aspendi, ubi largius coquitur,
 “ et usque ad medium lacum.” Plin. *Natur. Hist.*
 Lib. xxxi. c. vii.

² This account is extracted from the Polish historian Cromerus. See *Phil. Transactions abr. by Lowtherp*, vol. ii. p. 525.

³ Dr. Thomas Humphrey, who was physician to the army under Field Marshal Lacy, in the last expedition of the Russians against Crim Tartary, where he died of a contagious distemper.

in

in the summer season, travelled over vast desert plains, where grew neither tree nor herb, and which, for many miles together, were covered over with salt ⁴.

WE are told of a falina of this kind in the West Indies, called Garci Mendoza, forty leagues long, and sixteen broad ⁵. But the learned Doctor Shaw hath given us the most accurate description of several of these falines in the kingdom of Algiers ⁶, which

⁴ The Valley of salt mentioned in sacred Scripture, where David smote the Syrians, and slew 18,00 of them, is supposed to be that nigh Tadmor: another of the same kind there is nigh Aleppo. *Ph. Tr.* N^o. 27.

⁵ “ The salt pits called Garci Mendoza, are none of
 “ the most inconsiderable wonders of this new world.
 “ Those pits are called Garci Mendoza, for their big-
 “ ness, because they be forty leagues long, and, where
 “ narrowest, sixteen broad. And also because that
 “ sometimes in the middle of that space are disco-
 “ vered as it were wells that have no bottom, and
 “ great overgrown fishes are seen in them. It is very
 “ dangerous travelling over this space of ground, for
 “ fear of losing one’s eye-sight; because the great
 “ glistering of the sun beams upon that place of
 “ crystal, puts out one’s eyes, unless they be defend-
 “ ed with black tiffany. There is danger of life,
 “ also, in that journey: it having happened, that going
 “ over that place, the traveller and his horse have both
 “ been swallowed up, leaving no manner of mark
 “ behind either of them.” *Alonso Barba.*

⁶ “ The salt pits of Arzew lye surrounded with
 “ mountains, taking up an area of about six miles in

in winter are salt lakes, but dry plains in summer; at which season large quantities of salt are dug out of them for sale. Salinas of the same kind have been taken notice of by travellers, in many other parts of the world; but these already mentioned are sufficient for our present purpose.

C H A P. III.

Of bay salt drawn from the brine of ponds and lakes and first of salt thus prepared; in the Capè de Verd islands.

ALthough the English have, for a long time, prepared vast quantities of bay salt in the Cape de Verd islands; yet no one

“ compass. They appear like a large lake in winter,
 “ but are dry in the summer, the water being then ex-
 “ haled, and the salts left behind crySTALLIZED. In dig-
 “ ging they pass through different layers of this salt,
 “ whereof some are an inch, others more in thickness, in
 “ proportion, I presume, to the saline particles the wa-
 “ ter was impregnated with, before their respective
 “ concretions. This whole area is made up of a
 “ succession of such similar strata heaped one upon
 “ another: and in the same manner are the salinæ
 “ betwixt Carthage and the Gulletta, those of the Shott,
 “ and of other places, either bordering upon, or lying
 “ within the Sahara.” Dr. Shaw’s *Travels*, p. 229.

“ Of the like quality and flavour is the salt of
 “ the lake of Marks, and other lesser plains of the
 hath

hath hitherto given so exact and clear an account of the method of preparing it there, as the nature of the subject doth seem to require. The following account was collected chiefly from the relations of several persons of credit, who themselves assisted in making salt at those islands.

THE Cape de Verd isles which afford salt, are chiefly Mayo, Bonavista, and Sall. The subjects of Great Britain have enjoyed the privilege of making salt, at certain salinæ in the two first mentioned islands, exclusive of all other nations, ever since the marriage of king Charles the Second with the Infanta of Portugal. They do not pay any acknowledgment to the king of Portu-

“ same nature. These are usually called Sibkah, or
 “ Shibkah, *i. e.* saltish plats of ground; being com-
 “ monly overflowed in winter (at which time they ap-
 “ pear like so many extensive lakes) but dry all sum-
 “ mer, when they may be taken for so many bow-
 “ ling greens, prepared for the turf. Some of these
 “ Shibkahs have a hard and solid bottom, without
 “ the least mixture of gritty mould, retaining the salt
 “ that lyeth crytallized upon them after rain. But others
 “ are of a more oozy absorbent nature, seldom pre-
 “ serving any saline incrustations upon the surface. The
 “ chief substratum of the Shibkah El Low-diah is,
 “ like a tessellated pavement, made up of various little
 “ cubes of common salt.” *Id.* p. 230.

gal for this privilege ; only, of late years, he hath imposed a tax, paid by the British captains for every afs which they hire of the inhabitants to carry the salt to their boats. The time of making the salt, is in the dry season of the year ; which, in those islands, is usually from the latter end of November, to the beginning of July. Those, therefore, who would load with salt, endeavour to be there in the month of December, or January. On the west side of Mayo, or May, they bring their ships to anchor in a pretty good road, at a hundred or two hundred yards distance from the shore. As soon as they are on shore, they find themselves upon a bank of light loose sand, fifty or sixty yards broad. And when they have passed this bank, they enter upon the salina, or salt marsh ; which lies between the sand bank, and some small hills beyond it. This salina is a plain, about half a mile broad and a mile long, the greatest part of which is hollowed out in salt pits, filled at the proper season of the year with a strong brine, or pickle (as the sailors term it) to the depth of about eight inches.

SEVERAL writers assert, that this brine is only sea water, which flows through a
hole

hole in the sand bank, like a sluice, and that, only at spring tides. Those that I have conversed with, who made salt there, could give no certain information in this particular, only said they had never seen any such sluice, but had observed more brine in the salt pits at spring tides, than at other times. But, as it is certain that there are several salt ponds in Bonavista and Sall, which have no communication with the sea; and that all the springs nigh the salina in the isle of May have a brackish taste, and are impregnated with salt; and that the brine in the pits is much stronger than sea water; and that it is weakest in the pits which are farthest from the sea, growing stronger as it falls by a gentle descent into the pits which are nigher the shore; these and other reasons seem to prove, that this strong brine does not proceed from the sea, but springs from the hills adjoining to the salt marsh. And this may possibly be the case, although it should be true, that the brine stands higher in the pits at spring tides, than at other times. For the sea water, although it may not flow into the pits at spring tides, may notwithstanding at such times rise so high, as to prevent the brine from draining out of them through the

C. 2

sand;

sand ; and may have the same effect with a dam, and so cause the brine to stand higher in the pits at spring tides, than at other times ¹.

HOWEVER this be, it is certain that at the proper season of the year, the sailors commonly find all these pits filled with a very strong brine, or pickle ; but sometimes, after long droughts, they find it more scarce, and then dig little wells, from which they fill

¹ An instance of the same kind I have observed in some wells, sunk nigh the sea shore, which commonly afford plenty of fresh water ; but in very dry seasons, have only held water when the tide was in, and were empty when the tide was out. The springs which supply these wells, run through a large bed of gravel, out of which the water flows, between the full sea and low-water mark. When, therefore, the said stratum of gravel is quite filled with water, there is constantly plenty of it in the wells ; but in great droughts, when the springs are low, all the water in the said stratum runs beneath the bottoms of the wells, and springs out on the sea shore, a little above the low-water mark ; except at such times as the tide is in ; for then, the sea water has the effect of a dam, and retains the fresh water in the stratum of gravel, till it rises higher than the bottoms of the wells ; which are therefore supplied with water ; until the sea returning back, gives it liberty again to spring out on the shore. The colliers also in sinking a coal pit nigh Whitehaven, about fifty or sixty yards from the sea shore, when they had sunk to the level of the sea, observed the water at the bottom of the pit, to ebb and flow constantly with the tide.

their

their salt pits to the depth of eight inches. The bottom of these pits is a kind of oozy mud that retains the brine. The sailors make them of various forms and sizes, according to their fancy. Those who first arrive cleanse out as many of these pits from mud and dirt, as they have occasion for; the next ship's company do the same, and so successively, till all the pits are taken up; and if any more ships arrive, they are obliged to wait until those who have possession of the pits are served. As the fresh water exhales from the pits, the salt forms into crystals, which sink to the bottom of the brine. Twice a week they draw the salt out of the pits with rakes into little heaps: and after the brine is somewhat drained from it, they put it in barrows, and wheel it to their large heap, where it drains further, and soon becomes hard and dry, and fit to be put on board their ships. The inhabitants of the island willingly assist, for hire, in making the salt; and also provide asses to carry it to the sea side; from whence it is conveyed, by boats, on ship-board. And thus, if the weather be favourable, a large ship may be laden with salt in a fortnight; and frequently sooner, when

(as it often happens) the sailors, on their arrival, find the pits full of concreted salt.

BUT, on the contrary, it sometimes happens, that the rainy season continues longer than usual; and then, ships have been delayed several months before they could get their loading. At other times the rains have come on very soon; or the sea hath been so boisterous with tornadoes (as it usually is for a considerable time before the rains set in) that no salt could be shipped on board²; or by reason of tedious passages, ships have not arrived in due time. And by such accidents, many ships have been disappointed, and forced to leave these islands without their loading of salt³.

² These high winds also frequently injure the salt, by driving the sand amongst it.

³ This trade might therefore be carried on, with much greater advantage, if there was a British factory established in these islands, whose business it should be to make salt during the whole dry season, and to sell it to the British subjects, as cheap (which they well might) or even cheaper, than our sailors can now make it themselves; which, as I am informed, is seldom at a lower price than sixpence per bushel. By this means our vessels would not be disappointed of their loading, or detained so long as they now are; and the mariners would have nothing to do at these isles, but to ship the salt on board; which might speedily be done in large lighters, from wharfs provided for that purpose.

THE

THE salt is made exactly in the same manner at Bonavista as at the isle of May. The salinæ at both islands are nearly of the same magnitude ; that at Bonavista also lies beyond a sand-bank, which is about two hundred yards broad. But the brine is there weaker and does not kern ⁴ so fast as at the isle of May. And the sea being there very shallow, the ships are obliged to ride at anchor at a mile distance from the shore ; so that the sailors have there a good deal of trouble in shipping the salt. For these reasons our vessels seldom load there, when they can be supplied with salt at the isle of May. But although these isles are only about eighteen leagues distant from each other, yet the sailors have found by experience, that the rainy seasons sometimes begin several weeks sooner, or continue longer at one of these islands, than the other. Sometimes, therefore, when the weather proves unfavourable at the isle of May, or when there happens to be too great a crowd of ships there ⁵, the sailors find it more con-

⁴ To kern, is a term which the sailors use, signifying to corn, or to form into grains, or crystals of salts. Our salt-boilers call it graining, or salting.

⁵ There are frequently fifteen or sixteen ships loading

venient to load at Bonavista. The weather at these islands is seldom excessively hot, the heat of the sun being tempered by fresh breezes from the sea.

C H A P III. S E C T. II.

Of bay salt made at Tortugas and other places in America.

OUR American colonies have, for near a century past, been supplied with large quantities of bay salt from Salt Tortuga, one of the Leeward islands, uninhabited, situated nigh the coast of Caraccos on the Spanish main¹; also from Turks island, which lies not far from Hispaniola²; and many vessels freighted from North America

with salt at the isle of May. Some have known fifty ships there together.

¹ The Dutch also draw large quantities of salt from some ponds in Bonairy, an island belonging to them, not far distant from Salt Tortuga.

There are also considerable quantities of salt made in several of the Caribbee islands, particularly at Anguilla, St. Martin's, and St. Christopher's.

² Dampier informs us, that there is a pretty good road on the south east side of this island, and that the salina lies adjoining to it, within two hundred paces of the sea; and that, in peaceable times, he had seen above twenty sail of ships in this road at one time, come to load salt.

to

to Barbadoes, and others of the Caribbee isles, were accustomed to go from thence to these salt islands, and carry back a loading of salt; for which they found a market in Newfoundland, New-England, and other British colonies in North America.

THE Spaniards, for a long time, gave the British subjects no molestation in this trade. But, a few years before the present war between the two nations broke out, they began to seize all British ships laden with salt, which they met with nigh their settlements, claiming the sole property of these salt islands. The British subjects, unwilling to lose so valuable a branch of trade, which they had long enjoyed without any interruption, resolved to maintain themselves in it by force; therefore went no more in single ships, but in large fleets of armed vessels. These vessels usually joined fleet at Barbadoes, or some other of the Caribbee islands, where seventy or eighty sail of them would sometimes muster. Before they set forward upon the voyage, they chose a commodore, who had the chief command, and entered into engagements for their mutual defence; and then set sail, usually about the beginning of March. They commonly went to Tortu-
ga;

ga; where, as soon as they arrived, they divided the salinæ into several portions, allotting one for each ship, according to its burden. Each ship's company then used what diligence they could in collecting the salt that fell to their share, and wheeling it down to the shore, thence carried it in boats on board their ship. They commonly found salt enough to load the whole fleet; but it sometimes fell short, either when the fleet was too numerous, or when the season proved unfavourable. As soon as they had done shipping the salt, the whole fleet set sail together, and remained united, until they thought themselves out of danger from the Spanish Guarda costas; and then each ship steered towards its intended port.

THE method of making salt at Tortuga and Turks island is much the same as that practised in the Cape de Verd isles; only, in the American isles, they do not collect it out of small pits, but larger ponds. The sailors, on their arrival, often find large quantities of fine clear salt lying at the bottom of these ponds, from whence they rake it out.

MANY have related, as something very extraordinary, that in these American islands the salt kerns, or forms into grains, only during

ing the wet season of the year. But they are certainly mistaken who think that any salt is formed in these islands during the continual rains which fall in the wettest season ; or that the brine in the ponds will not let go its salt, until it is diluted and made weaker by rains. The truth of the matter is probably this : During the constant rains, such vast quantities of water fall, that the salt lakes overflow, and large quantities of salt are washed quite away. After the rain ceases, the ponds remain filled with a weak brine, so that no salt can crystalize in them till most of the water is exhaled ; which does not happen till towards the time that the rainy season again sets in. But in the countries lying between the tropics, which have their dry and wet seasons, the rains almost constantly come on in tornadoes, or thunder showers, which for the first month, or six weeks, only fall once a day, and sometimes only once in two or three days ; especially in these islands, which are not subject to such long and violent rains as many parts of the continent lying under the same degrees of latitude. These tornadoes therefore, wash much salt from the surface of the earth into the ponds, and also supply the springs with
water,

water, which being impregnated with salt in its passage through the earth, continually replenishes the ponds with brine. But when the weather continues excessively dry, these springs are dried up, and no more brine flows into the ponds. These tornadoes, therefore, do not contribute towards crystalizing the salt; but only replenish the ponds with brine, which is reduced into salt by the heat of the sun. So that whilst the rains are moderate, and the water arises in vapours, as fast as it falls in dews and showers, large quantities of salt are made in the ponds. But as soon as the rains become excessive, and more water flows into the ponds than is exhaled from them, the brine becomes weak, and no more salt is extracted from it.

THIS account agrees well with what captain Dampier hath related concerning the method of making salt at the salinæ in the bay of Campeachy. His account is as follows.

“³ THE Salina is a fine small harbour for
“ barks, but there is not above six or seven

³ The same author gives the following account of the weather in the bay of Campeachy, which will serve to illustrate several particulars here taken notice of.

“ The dry season begins in September, and holds till
“ April, or May; then comes in the wet season, which
“ feet

“ feet water. And close by the sea, a lit-
“ tle within the land, there is a large salt
“ pond belonging to Campeachy town,
“ which yields abundance of salt. At the
“ time when the salt kerns, which is in May

“ begins with tornadoes, first one a day, and by degrees
“ increasing till June; and then you have set rains till
“ the latter end of August. This swells the rivers so
“ that they overflow, and the Savannahs begin to be
“ covered with water; and although there may be some
“ intermission of dry weather, yet there are still plenti-
“ ful showers of rain, so that as the water does not in-
“ crease, neither does it decrease, but continues thus
“ till the north winds are set in strong, and then all the
“ Savannahs, for many miles, seem to be but part of the
“ sea. The norths do commonly set in about Octo-
“ ber, and continue by intervals till March. — These
“ winds blowing right in on land, drive the sea, and
“ keep the tides from their constant course as long as
“ they last, which is sometimes two or three days; by
“ this means the freshes are pent up, and overflow much
“ more than before, though there be less rain. They
“ blow most fiercely in December and January; but
“ afterwards they decrease in strength, and are neither
“ so frequent nor lasting; and then the freshes begin
“ to drain from off the ground. By the middle of Fe-
“ bruary the land is all dry; and in the next month
“ perhaps you will scarce get water to drink, even in
“ those Savannahs that but six weeks before were like a
“ sea. By the beginning of April, the ponds also in
“ the Savannahs are all dried up, and one who knows
“ not how to get water otherwise may perish for thirst.
“ But those who are acquainted here, in their necessity
“ make to the woods, and refresh themselves with wa-
“ ter that they find in wild pines.” Vol ii. p. 2.

“ or

“ or June, the Indians of the country are
 “ ordered by the Spaniards to give their at-
 “ tendance, to rake it ashore, and gather
 “ it into a great pyramidal heap, broad be-
 “ low, and sharp at the top like the ridge
 “ of a house ; then covering it all over with
 “ dry grafs and reeds, they set fire to it, and
 “ this burns the out side salt to a hard black
 “ crust. The hard crust is afterwards a de-
 “ fence against the rains that are now set in,
 “ and preserves the heap dry, even in the wet-
 “ test season⁴. The Indians, whose business
 “ I have told you, is to gather the salt thus
 “ into heaps, wait here by turns all the kern-
 “ ing season, not less than forty or fifty fa-
 “ milies at a time. — When the kerning
 “ season is over, they march home to their
 “ settled habitations, taking no more care
 “ about the salt. But the Spaniards of Cam-
 “ peachy, who are owners of the ponds, do
 “ frequently send their barks hither for salt
 “ to load ships that lie in Campeachy road ;
 “ and afterwards transport it to all the ports
 “ in the bay of Mexico, especially to Alva-
 “ rado and Tompeck, two great fishing

⁴ This method of preserving salt from rains is also practised in the Cape de Verd islands.

“ towns,

“ towns, and I think that all the inland
 “ towns thereabouts are supplied with it.”

C H A P. IV.

*Of marine bay salt prepared in France and
 other parts of Europe.*

TH E most perfect works of art are generally the truest imitations of nature. Hence some have thought, that those artificial methods which have been invented for preparing salts, and extracting them from water, were borrowed from those more simple methods by which men observed those salts to be separated from their watery vehicle without the help of art¹. This opi-

¹ “ Initio solertes homines cum viderent aquas quorundam lacuum, natura succi plenas, solis ardoribus ficcatas conspissari, atque ex eis fieri succos concretos; verisimile est, eos, aquas affimiles aliis in locis infudisse, vel corrivasse in areas ad aliquam altitudinem depressas, ut ipsas etiam solis calores condensarent. Deinde, quia viderent ista ratione succos concretos tantummodo æstate confici posse, nec tamen in omnibus regionibus, sed in calidis et temperatis solum, in quibus æstivo tempore raro pluit; eas quoque in vasis igne subjecto coquere ad spissitudinem cœpisse: quo modo omnibus anni temporibus, in omnibus regionibus, etiam frigidissimis, ex aquis succosis, sive natura sive ars eas infecerit, coctis succi concreti confici possunt.” Agricola *De re metallicâ*, Lib. xii.

nion seems to be countenanced by the great resemblance that may be observed between those plain and simple methods of preparing bay salt already related, and those more artful methods of preparing it from sea water, which have long been practised in Europe, and which it will be proper in the next place to describe.

BAY salt is not extracted from sea water in the colder parts of Europe ; as on the sea coasts of Germany, Denmark, and Sweden ; but in places situated in a more southern climate, where the heat of the sun is more intense, as on the coasts of France, Spain, and Italy. Some marine bay salt hath also of late years been made in England, at Lymington, and other parts of Hampshire, and in the isle of Wight ; but in those places, only in the drier summers, and then, rather by accident than design ; it being collected from certain ponds which were originally made for heightening sea water, or reducing it into a strong brine by the heat of the sun, in order to lessen the expence of fuel in boiling it into white salt².

² In dry summer weather considerable quantities of bay salt may also be collected on the English shores in hollows of the rocks, where the sea-water hath been left by the tide.

THE ponds in which this salt is made do nearly resemble a rude kind of salt-marsh described by Agricola³, in which the seawater is received from a pool into a trench; and from thence derived by sluices into several pits dug out of the earth; and when it hath stood some time in these pits, it is let out into others, where it stands a certain time according to the heat of the weather; and then is made to flow by sluices into other pits; till at length, being reduced to a strong brine, it is suffered to stagnate in pits; where the salt crystallizing, is from thence at proper times drawn out⁴.

BUT the French marshes, in which immense quantities of salt are annually prepared, are contrived after a much more artful manner. And as they are ~~the most~~ commodious that have hitherto been invented, it may be proper here to transcribe an account of them, as given by an ingenious French physician, and published in the *Transactions of the Royal Society*⁵.

³ *Dere metallica*, Lib. xii.

⁴ A description of the Hampshire works, see afterwards in Part ii.

⁵ The following is the account published by Lowthorp in his *Abridgment*, Vol. ii. p. 363. and is almost the same verbatim with that in the *Transactions*, N^o 51. p. 1425.

“ Plate 1. *AAA*. is the sea.

“ 1.1. The entry by which the sea water
passes into *B B*.

“ *B B*. The first receptacle, in which the
“ water maketh three turnings as you see,
“ and is ten inches deep⁶.

“ 2.2. The opening, by which the first
“ and second receptacle have communication
“ one with another⁷.

“ *EEF*. The third receptacle is properly
“ called the marsh.

“ *ddd*. Is a channel very narrow, through
“ which the water must pass before it enters
“ out of the second receptacle into the
“ third.

“ 3.3. Is the opening, by which the water runs
“ out of the second into the third receptacle.
“ The pricks you see in the water throughout
“ the whole scheme, do mark the course and
“ turnings which the water is forced to make
“ before it comes to *bbbb*, which are the
“ places where the salt is made.

only a few particulars are here omitted which do not
relate to the subject.

⁶ It is in the second receptacle *CC* that the water makes
three turnings.

⁷ This opening is more conveniently made in this place
than at * where the sea water in the first re-

“ *bbbb*.

“ *bbbb*. Are the bed of the marish where
 “ the salt is made, and in them the water
 “ must not be above an inch and a half deep.
 “ Each of these beds is fifteen foot long,
 “ and fourteen foot large^s.

“ 9999. Are the little channels between
 “ the beds.

“ 8888. Are the apertures by which the
 “ beds receive the sea water after many
 “ windings and turnings.

“ WHEN it rains the openings 2.2. 3.3.
 “ are stopped to hinder the water from run-
 “ ning into the marish. Unless it rain much,
 “ the rain water doth little hurt to the
 “ marish; the heat of the sun sufficiently
 “ exhaling it, if it be not above an inch high;
 “ only if it have rained very plentifully that
 “ day, no salt is drawn for the three or four
 “ next days. But if it rain five or six days,
 “ the people are then necessitated to empty
 “ all the water off the beds by a peculiar
 “ channel, which cannot be opened but
 “ when it is low water. But it is very fel-
 “ dom that it rains so long as to constrain
 “ men to empty those beds. The hottest

ceptacle is strongest than (as in the *Ph. Tr.*) at ** which
 seems too nigh the entry of the sea.

^s And framed on every side with wood.

D 2

“ years

“ years make the most salt, and in the hot-
“ test part of the summer there is salt made
“ even during night. Less salt in calm than in
“ windy weather.

“ THE west and north west winds are the
“ best for this purpose.

“ OUR country people draw the salt every
“ other day, and every time more than an
“ hundred pound weight of salt.

“ THE instruments used to draw the salt
“ have many small holes to let the water
“ pass, and to retain nothing but the
“ salt.

“ THE reddish earth in the marishes
“ make the salt more gray, the blueish
“ more white. Besides if you let run in a
“ a little more water than you ought, the
“ salt becomes then more white, but then it
“ yields not so much. Generally all the
“ marishes require a fat earth, neither spungy
“ nor sandy.

“ THE salt man who draws the salt must
“ be very dextrous. In this isle of Rhee,
“ men there are that draw very dark salt,
“ and others that draw it as white as snow;
“ and so it is at Xaintonge. Chiefly care is
“ to be taken that the earth at the bottom of
“ the beds mingle not with the salt.

“ THE salt we use at our tables is perfectly white, being the cream (or that salt which is formed on the top of the water) drawn four or five hours before the salt is to be drawn. The grains of it are smaller than of the other. Generally the salt of Xaintonge is somewhat whiter than ours. The bigness of our salt is the size of a pepper grain, and of a cubical shape.

“ The marishes are preserved from one year to another, by overflowing them a foot high.

“ THE timber of the marishes, if it be of good oak, keeps near thirty years; but there is used but little wood, all the ditches and apertures, being done with stones.”

THE foregoing description being in some parts obscure, and in others imperfect, it is necessary to add to it a few remarks by way of explanation; that the construction of the French salt-marsh, and the method of preparing salt therein may be better understood. And this seems the more necessary, since, although the above account of the French method of making salt hath long been published, yet it hath not been brought into use, neither in Great Britain nor in the British colonies in America.

THOSE therefore, who would make a salt marsh, commonly chuse a low plat of ground adjoining to the sea, distant from the mouths of large rivers, but nigh a convenient harbour for boats or larger vessels. This ground must be free from springs of fresh water, and no ways subject to land floods ; and, if possible, should have a clayey bottom ; it should also be defended from the sea either by banks of rising ground, or by an artificial mole raised for that purpose.

THE ground so chosen must be hollowed out into three ponds or receptacles. The first, into which the sea water is usually admitted, may be called the reservoir. The second receptacle (which is divided into three distinct ponds, communicating with each other by narrow passages, and containing brine of different degrees of strength) may be called the brine ponds. The third receptacle is furnished with an enterance, between which and the brine ponds there runs a long, winding, narrow channel ; the rest of it is divided into several shallow pits containing a fully saturated brine, which in them is converted into salt, and may therefore be distinguished by the name of the salt pits.

THE

THE first receptacle or reservoir must have a communication with the sea by a ditch defended on each side with walls of brick or stone ; and made of such a depth that by it all the water contained in the reservoir and other parts of the salt marsh may flow out at low water ; and by it also the sea water may be admitted into the reservoir at full sea ; so that, at neap tides, the marsh may be filled with sea water to the depth of ten inches in the reservoir ; and consequently at higher tides, to the depth of two feet, when there is occasion to overflow the marsh, as is done in the winter season when no salt is made ; by which means the wood work is longer preserved from decay, and the bottom of the marsh from frost and other injuries. And in order that the marsh may be thus overflowed when occasion requires, it is necessary that the several receptacles should be sunk so deep that the ground on all sides may be sufficiently elevated to keep in the sea water at the depth above mentioned. The ditch between the sea and the reservoir must also be provided with a sluice or floodgate, by which the sea water may be admitted, retained, or let out, and

the whole salt marsh drained as occasion may require.

THE several ponds or receptacles must not have their bottoms all upon the same level, but must be made of unequal depths; so that the first receptacle or reservoir must be eight inches and a half deeper than the salt pits in the third receptacle. The three brine ponds, situated between the reservoir and the salt pits must also be of unequal depths, that adjoining to the reservoir being the deepest, and that, which is nearest the salt pits, the shallowest; but all of them must be shallower than the reservoir. And the three receptacles being thus constructed; the water standing at the same height in them all, and forming with its surface one continued plain, will be ten inches deep in the reservoir, when only an inch and a half deep in the salt pits.

THE judicious French author hath not given us any account of the length and breadth of the reservoir and brine ponds, but some judgment may be formed of their size from his plan of the whole work. It will be better to err by making them too large, than too small. In general, they ought to be large enough to furnish the salt pits

pits with a constant supply of brine fully saturated with salt ; and for that purpose it is necessary to have them of different dimensions in different countries, as will be hereafter explained.

IT is not necessary that the reservoir should be exactly of the form which the French author hath described, where the ground will better admit of another, that may be chosen. And even the brine ponds, and salt pits may be made of different forms, if due regard be had to the general contrivance of the whole work.

FOR the bottoms of the reservoir and brine ponds any kind of tough, lean clay, or earth, that will hold water, may serve very well. The French make the bottoms of their salt pits of any blue or red clay they meet with ; but in order to have a white clean salt, it is necessary that those pits should be carefully laid with some strong cement that will retain the brine, and cannot easily be broken up. As to other particulars relating to the structure of the French salt marsh, they are sufficiently explained by the ingenious physician whose account is before inserted.

THE marsh being thus constructed ; the
salt

salt men, at the proper season of the year, open the floodgate when the tide is out, and drain off all the stagnating water; and, if there be occasion, repair the bottom of the marsh, and cleanse its several receptacles from mud and dirt. Afterwards, when the tide rises, they, by the same floodgate admit the salt water into the marsh, 'till it stands in the reservoir at the height of ten inches. In a day or two, most of the water in the salt pits is exhaled, and what remains in them is a very strong brine. They then let in more sea water; and so take care, every two or three tides (oftener or seldomer as occasion requires) to admit as much water into the reservoir as will supply the place of that which hath been wasted in vapours; constantly raising it to the height of ten inches in the reservoir; and consequently, to an inch and an half in the salt pits⁹. All the parts of the marsh are thus supplied with water out of the reservoir; but the sea water, which flows into the reservoir, is not confusedly mixed with the saltier water contained in other parts of the work. For, as the se-

⁹ When the Weather is exceeding hot, and there are dry winds, the pits should be filled higher, than when the weather is more temperate and the air more moist.

veral parts communicate only by narrow passages ; it is provided. that the salt water, flowing out of the reservoir, never returns there again ; but gently flows along till it arrives at the second brine pond, and afterwards at the third ; being forced forward by the sea water, and from time to time received into the reservoir. During this flow course, the watery fluid continually flies off in exhalations, and the brine is continually preparing for crystallization as it gently flows along, growing stronger and stronger the nearer it approaches to the salt pits. So that when it enters these pits, it is fully saturated with salt. And particular care is taken to guard the entrance of the salt pits with a long winding narrow channel ; by which means the strong pickle contained in these pits is prevented from returning back, and mixing with the weaker brine in the brine ponds. Care is also taken that the strong pickle in the salt pits be spread out very thin to the sun and air, with a large surface ; by which means the watery vapours more quickly exhale from it, leaving the salt concreted into crystals. These the salt men carefully draw out, and oftentimes dispose into large pyramidal heaps ; which they thatch
over

over with straw, and so preserve them from the injuries of the weather. Thus, at a small expence and trouble a salt is prepared which is found extremely fit for all domestic uses ; and thus France is also furnished with a very profitable article for exportation into foreign countries.

THE French have so many works of this kind, that an ingenious author of that nation affirms, that, in favourable seasons, as much salt is sometimes made in a fortnight as is sufficient for the whole annual consumption of that kingdom, and of all those other nations who purchase much more of it than the French consume themselves ; but after a rainy summer there is often a scarcity of salt, and the price of it increases.

P A R T II.

The A R T of preparing
W H I T E S A L T.

C H A P. I.

Of W H I T E S A L T in general.

ALTHOUGH, in warm climates, salt is made, with the greatest ease, and at the least expence, by the heat of the sun, after the methods already described; yet, in several countries, where bay salt might be conveniently made, they prepare all their salt by culinary fires. Thus in Austria, Bavaria, and many other parts of Germany, and also in Hungary, and even
in

in some parts of Italy¹, they constantly boil the water of their salt springs into white salt; either because the custom of making salt in that manner hath long prevailed, and less expensive methods have not been thought of; or else, because in those inland countries, they have no great occasion for very strong salt to cure provisions, and esteem white salt more beautiful and fitter than bay salt for the uses of the table; or lastly, because, in those countries, they are unwilling to waste any of their brine, which could not be converted into salt by the heat of the sun during the winter season. But in other parts of Europe, as in Britain, and in the northern parts of France and Germany, an erroneous opinion long prevailed, that the heat of the sun was not there sufficiently intense, even in the summer season, to reduce sea water, or brine into bay salt. And all arguments would probably have been insufficient to remove this prejudice from the English, had not the

¹ “Tales salinæ extant in Volaterrano, ubi collecta
 “aqua e puteis altissimis, et in cortinis plumbeis decocta,
 “in salem paulatim densatur, qui omnium albissimus
 “ac tenuis, in lautis mensis eligitur: unicum hodie
 “illi civitati vectigal.” Baccius, *De Therm.* L. v.
 Cap. 4.

contrary

contrary been fully proved by experiments. which were first accidentally made in Hampshire. However, the method of making salt by coction will probably still continue to be practised in Britain ; as the salt so prepared is for several uses preferable to bay salt ; and when prepared after a particular manner, is preferable to common bay salt, even for curing provisions, as the practice of the Hollanders doth sufficiently testify. So that the due and right preparation of white salt seems very deserving of the notice and regard of the public.

WHITE salt, as it is prepared from various saline liquors, may therefore be distinguished into the following kinds². viz.

1. Marine boiled salt ; which is extracted from sea water by coction.

² Under the heads here given may be included all kinds of white salt now in use ; although other kinds differing at least in preparation from those here mentioned may probably be used hereafter ; as the refined white salt recommended in the fourth part of this work. Other kinds have also formerly been in use, as salt boiled in earthen vessels by the heat of natural baths, of which George Agricola gives the preparation, Lib. xii. *De re metallica*. Also that kind of salt said to be made in Lorraine, by casting salt water upon hot plates of iron, as Monsieur Pomet relates, *Histoire des Drogues*, Lib. iii. C. 13.

2. Brine

2. Brine or fountain salt, prepared by coction from natural brine whether of ponds and fountains, or of ponds, lakes, and rivers.

3. WHITE salt prepared from sea water, or any other kind of salt water, first heightened into a strong brine by the heat of the sun, and the operation of the air.

4. WHITE salt prepared from a strong brine or lixivium drawn from earths, sands, or stones impregnated with common salt.

A yet more rude method of preparing salt was practised by the ancient Gauls, Germans, and Spaniards, as Tacitus and others testify. The salt by them prepared might have some pretensions to the name of a boiled salt, although it was not white, but black. Pliny gives the following account of it. “*Galliæ, Germaniæque, ardentibus lignis aquam salis infundunt. — Quercus optima, ut quæ per se, cinere sincero, vim salis reddat: alibi corylus laudatur; ita, infuso liquore, carbo etiam in sale vertitur. Quocunque ligno confit, sal niger est.*” *Hist. Nat. L. xxxi. c. 7.*

Doctor Beal observes, that “in Varro’s days, it was the reproach of our Trans Alpines (who dwelt much farther towards the south than we do) that on the Rhine, *Nec vitis, nec olea, nec poma nascerentur; ubi sale nec fossilem, nec maritimum haberent; sed ex quibusdam lignis combustis, carbonibus salis, pro eo uterentur.*” Varro, *de re rust. L. i. c. 6.* — The world (remarks that judicious physician) is much amended since those days, on this side the Alps. And the English may yet be minded to proceed as far as they can, to remove the reproach, at least for *fruit, wine, and salt.*” *Ph. Tr. N°. 103, p. 48.*

5. RE-

5. REFINED rock salt ; which is boiled from a solution of fossil salt in sea water, or any other kind of salt water, or pure water.

6. LASTLY, salt upon salt ; which is bay salt dissolved in sea water, or any other salt water, and with it boiled into white salt.

UNDER these heads may be ranked the several kinds of boiled salt now in use. It will be proper therefore to treat the preparation of these several kinds of common salt, in the same order in which they are here enumerated.

CHAP. II. SECT. I.

Of salt boiled from sea water.

THE method of extracting salt from sea water by coction is only practised in places where great plenty of fuel can be had at a very low price ; and therefore is used in few countries except on those parts of the British coasts which most abound with pit coal, as at North and South Sheilds, Blyth, and other places in Northumberland and Durham¹ ; from whence this salt is ex-

¹ In these two counties they have about two hundred
E ported

ported in large quantities, under the name of Newcastle salt, to London and other parts of England, and to Denmark, Norway, and other northern countries. Much of this salt is also made on the coasts of Cumberland; and at several works situated on the Firth of Forth, and at Air and Saltcotes in Scotland; at all which places the worst of their coals are applied to this use.

THE works for making this salt are variously constructed in various places; those seem best contrived which are made after the following manner.

AT some convenient place near the sea shore is erected the *saltern*². This is a long, low building, consisting of two parts; one of which is called the fore-house, and the other the pan-house or boiling house. The fore-house serves to receive the fuel, and cover the workmen; and in the boiling house are placed the furnace, and pan in which the salt is made. Sometimes they have two pans, one at each end of the saltern; and the part appropriated for the fuel and workmen is in the middle.

pans at work, in which they annually prepare eleven or twelve thousand tons of salt.

² See Plate II. Fig. 1.

THE furnace ³ opens into the fore-house, by two mouths, each of which is a mouth to the ash pits. To the mouths of the furnace, doors are fitted; and over them a wall is carried up to the roof, which divides the fore-house from the boiling-house, and prevents the dust of the coal, and the ashes and smoke of the furnace from falling into the salt pan. The fore-house communicates with the boiling house by a door placed in the wall which divides them.

THE body of the furnace ⁴ consists of two chambers divided from each other by a brick partition called the mid-feather; which from a broad base terminates in a narrow edge nigh the top of the furnace; and by means of short pillars of cast iron erected upon it, supports the bottom of the salt pan; it also fills up a considerable part of the furnace, which otherways would be too large, and would consume more coals than, by the help^d of this contrivance, are required. To each chamber of the furnace is fitted a grate, through which the ashes fall into the ash

³ See a representation of the front of the furnace Plate III. Fig. 2.

⁴ See Plate III. Fig. 2.

pits⁵. The grates are made of long bars of iron, supported underneath by strong cross bars of the same metal. They are not continued to the farthest part of the furnace, it being unnecessary to throw in the fuel so far; for the flame is driven from the fire on the grate to the farthest part of the furnace; and from thence passes together with the smoke, through two flues into the chimney⁶; and thus the bottom of the salt pan is every where equally heated.

THE salt pans⁷ are made of an oblong form, flat at the bottom, with the sides erected at right angles; the length of some of these pans is fifteen feet, the breadth twelve feet, and the depth sixteen inches, but at different works they are of different dimensions⁸. They are common-

⁵ At several salt works, particularly at most of those nigh Newcastle, they have neither grates, nor ash pits, but make their fires upon hearths.

⁶ See Plate IV. Fig. 1 and 2.

⁷ Where they make their fires on hearths, the chimneys are usually carried up at the end of the pan adjoining to the fore-house.

⁸ At many works they use pans of a much less size than here described. But those used at Shields and other places nigh Newcastle are much larger, being commonly twenty one feet long, twelve feet and a half broad, and fourteen inches deep, being the largest salt pans used any where in Great Britain.

ly made of plates of iron⁹, joined together with nails, and the joints are filled with a strong cement. Within the pan five or six strong beams of iron are fixed to its opposite sides, at equal distances, parallel to each other and to the bottom of the pan, from which they are distant about eight inches. From these beams hang down strong iron hooks, which are linked to other hooks or clasps of iron firmly nailed to the bottom of the pan; and thus the bottom of the pan is supported and prevented from bending down or changing its figure¹⁰.

THE pan, thus formed, is placed over the furnace, being supported at the four cor-

⁹ The Plates most commonly used are of malleable iron, about four feet and a half long, a foot broad, and the third of an inch in thickness. The Scotch prefer smaller plates, fourteen or fifteen inches square. Several make the sides of the pan, where they are not exposed to the fire, of lead; those parts, when made of iron, being found to consume fast in rust from the steam of the pan. Some have used plates of cast iron, five or six feet square, and an inch in thickness; but they are very subject to break, when unequally heated, and shaken (as they frequently are) by the violent boiling of the liquor. The cement most commonly used to fill the joints, is plaister made of lime.

¹⁰ See Plate III. Fig. 2. and Plate V. Fig. 2. from Agricola; in which the bottom of the pan is supported by wood beams fixed at a considerable height above the salt pan; as is still practised at several salt works.

ners by brick work ; but along the middle, and at the sides and ends, by round pillars of cast iron called taplins, which are placed at three feet distance from each other, being about eight inches high, and at the top, where smallest, four inches in diameter. By means of these pillars the heat of the fire penetrates equally to all parts of the bottom of the pan, its four corners only excepted. Care is also taken to prevent the smoke of the furnace from passing into the boiling-house, by bricks and strong cement, which are closely applied to every side of the salt pan¹¹.

BETWEEN the sides of the pan and walls of the boiling-house there runs a walk¹² five

¹¹ In some places, as at Blyth in Northumberland, besides the common salt pans here described, they have a preparing pan placed between two salt pans, in the middle part of the building, which in other works is the fore-house. The sea water being received into this preparing pan, is there heated and in part evaporated by the flame and heat conveyed under it through flues from the two furnaces of the salt pans. And the hot water, as occasion requires, is conveyed through troughs from the preparing pan into the salt pans. Various other contrivances have been invented to lessen the expence of fuel ; and several patents have been obtained for that purpose ; but the salt boilers have found their old methods the most convenient.

¹² See Plate III. Fig. 2.

or six feet broad, where the workmen stand when they draw the salt, or have any other business in the boiling-house. The same walk is continued at the end of the pan next to the chimney; but the pan is placed close to the wall at the end adjoining to the fore-house.

THE roof of the boiling-house is covered with boards fastned on with nails of wood, iron nails quickly mouldering into rust. In the roof are several openings, to convey off the watery vapours; and on each side of it, a window or two, which the workmen open when they look into the pan whilst it is boiling.

NOT far distant from the saltern, on the sea-shore, between full sea and low water marks, they also make a little pond in the rocks, or with stones on the sand, which they call their sump. From this pond they lay a pipe, through which, when the tide is in, the sea water runs into a well adjoining to the saltern; and from this well they pump it into troughs, by which it is conveyed into their ship or cistern, where it is stored up until they have occasion to use it.

THE cistern is built close to the saltern,

and ¹³ may be placed most conveniently between the two boiling-houses, on the back side of the fore-side of the fore-house ; it is made either of wood, or brick and clay ; it sometimes wants a cover, but ought to be covered with a shed, that the salt water contained therein may not be weakened by rains, nor mixed with foot and other impurities. It should be placed so high that the water may conveniently run out of it, through a trough, into the salt pans.

BESIDES the buildings already mentioned, several others are required ; as store houses for the salt, cisterns for the bittern, an office for his majesty's salt officers, and a dwelling house for the salt boilers.

ALL things being thus prepared ; and the sea water having stood in the cistern, till the mud and sand are settled to the bottom, it is drawn off into the salt pan. And at the four corners of the salt pan, where the flame does not touch its bottom, are placed four small lead pans called scratch pans, which, for a salt pan of the size abovementioned, are usually about a foot and an half long, a

¹³ Where there is only one salt pan the cistern is usually placed at the end of the boiling-house ; as in Plate II. Fig. 2.

foot broad and three inches deep, and have a bow or circular handle of iron, by which they may be drawn out with a hook, when the liquor in the pan is boiling.

THE salt pan being filled with sea water, a strong fire of pit coal is lighted in the furnace; and then, for a pan which contains about fourteen hundred gallons, the salt boiler takes the whites of three eggs¹⁴, and incorporates them well with two or three gallons of sea water, which he pours into the salt pan while the water contained therein is only lukewarm; and immediately stirs it about with a rake, that the whites of eggs may every where be equally mixed with the salt water.

As the water grows hot, the whites of eggs separate from it a black frothy scum, which arises to the surface of the water, and covers it all over. As soon as the pan begins to boil, this scum is all risen, and it is then time to skim it off.

THE most convenient instruments for this purpose are skimmers of thin ash boards six or eight inches broad, and so long that they

¹⁴ Instead of whites of eggs, at many salterns, as at most of those nigh Newcastle, they use blood from the butchers, either of sheep or black cattle, to clarify the sea water. And at many of the Scotch salterns they do not give themselves the trouble of clarifying it.

may

may reach above half way over the salt pan¹⁵. These skimmers have handles fitted to them; and the salt boiler and his assistant, each holding one of them on the opposite sides of the pan, apply them so to each other that they overlap in the middle, and beginning at one end of the pan, carry them gently forward together, along the surface of the boiling liquor to the other end; and thus without breaking the scum, collect it all to one end of the pan, from whence they easily take it out.

AFTER the water is skimmed, it appears perfectly clear and transparent, and they continue boiling it briskly, till so much of the fresh, or aqueous part is evaporated, that what remains in the pan is a strong brine almost fully saturated with salt, so that small saline crystals begin to form on its surface; which operation, in a pan filled fifteen inches deep with water, is usually performed in five hours.

THE pan is then filled up a second time with clear sea water drawn from the cistern, and about the time when it is half filled, the

¹⁵ See Plate VI. Fig. 3.

scratch pans are taken out, and being emptied of the scratch found in them, are again placed in the corners of the salt pan. The scratch taken out of these pans is a fine white calcareous earth found in the form of powder, which separates from the sea water during its coction before the salt begins to form into grains. This subtile powder, is violently agitated by the boiling liquor, until it is driven to the corners of the pan, where the motion of the liquor being more gentle, it subsides into the scratch pans placed there to receive it, and in them it remains undisturbed, and thus the greatest part of it is separated from the brine.

AFTER the pan hath again been filled up with sea water, three whites of eggs are mixed with the liquor, by which it is clarified a second time, in the manner before described; and it is afterwards boiled down to a strong brine as at first; which second boiling may take up about four hours.

THE pan is then filled up a third time with clear sea water; and after that a fourth time; the liquor being each time clarified and boiled down to a strong brine as before related; and the scratch pans being taken
out

out and emptied every time that the pan is filled up.

THEN, at the fourth boiling, as soon as the crystals begin to form on the surface of the brine, they slacken the fire and only suffer the brine to simmer or boil very gently. In this heat they constantly endeavour to keep it all the time that the salt corns or granulates, which may be nine or ten hours. The salt is said to granulate, when its minute crystals cohere together into little masses or grains, which sink down in the brine and lie at the bottom of the salt pan.

WHEN most of the liquor is evaporated, and the salt thus lies in the pan almost dry on its surface, it is then time to draw it out. This part of the process is performed by raking the salt to one side of the pan into a long heap, where it drains a while from the brine, and is then filled out into barrows or other proper vessels, and carried into the store house, and delivered into the custody of his majesty's officers. And in this manner the whole process is performed in twenty four hours; the salt being usually drawn every morning¹⁶.

¹⁶ From a pan fourteen feet and a half long, eleven feet and an half broad, and sixteen inches deep contain-

IN the store-house the salt is put hot into drabs¹⁷, which are partitions like stalls for horses, lined on three sides and at the bottom with boards, and having a sliding board on the fore side to put in or draw out as occasion requires. The bottoms are made shelving, being highest at the back side, and gradually inclining forwards; by which means the saline liquor, which remains mixed with the salt, easily drains from it; and the salt in three or four days becomes sufficiently dry,

ing about one thousand three hundred and five gallons, they draw from fifteen to twenty bushels of salt every day, each bushel weighing fifty six pounds.

At the salt works at Shields and other places in Northumberland and Durham they only draw their pans five times in a fortnight, filling them up seven or eight times in each process, and from each pan commonly obtain fifty six bushels of salt at a draught. They reckon that, in making a ton or forty bushels of salt, they consume three chaldrons of small pit coal, which cost them sixteen shillings and six pence; and pay to the salt boilers for their labour four shillings.

¹⁷ In some places, instead of these drabs, they use cribs, which are vessels like hay-racks, broad at the top, and tapering to a sharp bottom, with wooden ribs on each side placed so close that the salt cannot easily fall through them. At other works, as at Lemington, they use wooden troughs with holes at the bottom, through which runs the superfluous liquor into other troughs placed below to receive it. In other places they draw the salt into barrows, or wicker baskets, out of which the better liquor easily drains, as will be explained hereafter.

and

and is then taken out of the drabs, and laid up in large heaps, where it is ready for sale.

THE saline liquor which drains from the salt is not a pure brine of common salt, but hath a sharp and bitter taste, and is therefore called bitter¹⁸; this liquor at some works they save for particular uses, at others throw away. A considerable quantity of this bitter is left at the bottom of the pan after the process is finished; which, as it contains much salt, they suffer to remain in the pan, when it is filled up with sea water. But at each process this liquor becomes more sharp and bitter, and also increases in quantity; so that, after the third or fourth process is finished, they are obliged to take it out of the pan: otherwise it mixes in such quantities with the salt as to give it a bitter taste, and disposes it to grow soft and run in the open air, and renders it unfit for domestic uses.

AFTER each process there also adheres to the bottom and sides of the pan a white stoney crust of the same calcarious substance

¹⁸ The marine bitter is a ponderous liquor, exceeding clear, and almost as colourless as pure water; whereas the bitter drawn from some salt springs is of a brownish colour.

with

with that before collected from the boiling liquor. This the operators call stone scratch, distinguishing the other found in the lead pans by the name of powder scratch. Once in eight or ten days they separate the stone scratch from their pans with iron picks, and in several places find it a quarter of an inch in thickness¹⁹. If this stony crust is suffered to adhere to the pan much longer, it grows so thick that the pan is burnt by the fire, and quickly wears away.

C H A P. II. S E C T. II.

Miscellaneous observations and cautions relating to the foregoing process.

1. **I**N the foregoing process the salt begins to grain, or form into crystals immediately after the brine is brought to such a strength as to be fully satiated with salt; for if the evaporation be continued any further, the water remaining is not sufficient:

¹⁹ At Hall in Saxony they cleanse their salt pans from the stone scratch thrice a week, by removing them from off the furnaces, and setting them upon one side, then burning straw in them, by which the scratch is loosened, and falls off by beating the bottom and sides of the pan with a mallet.

to keep all the salt dissolved, which therefore begins to separate from it, and to concrete into crystals.

2. WATER is fully satiated with common salt, when each pound of it averdupois contains about six ounces of salt. For it hath been found by experiments, that so much salt and no more can be dissolved in pure water¹.

3. FOR the better understanding of the foregoing process it ought be considered that common salt, as well as the lixivial salt of vegetables, and several others of the more soluble kinds of salts, are dissolved in nearly equal quantities in cold water, and water of a boiling heat. Whereas tartar, nitre, several kinds of vitriol, and other salts, which are less soluble, or require a large proportion of cold water to dissolve

¹ Count Marfilli in his *Histoire phys. de la mer*, *Partie ii.* pag. 29. assures us that a pound of sea water can only dissolve an ounce, two drachms, and ten grains of salt; but in this and in several instances his experiments have not been made with sufficient accuracy. His error in this experiment seems to have arose from using the residuum of sea water evaporated to a dryness, which he mistook for pure marine salt; and observing some of it to subside and remain undissolved, he concluded that the sea water was fully saturated. More exactness
them,

them, may be dissolved in much greater quantities by hot than by cold water ³.

4. THE marine salt is therefore only separated (at least in any considerable quantities) from the water in which it is dissolved, during the time that the water exhales from it in vapours. Most of the salt being retained in cold water, which was dissolved in it

might be expected from the illustrious Mr. Boyle, although he only allows that one part of salt may be dissolved in five parts of pure water. Boerhaave comes nearer to the truth, when he affirms that pure water is fully satiated, when the proportion of salt is to that of the water as one to three and a quarter. But Dr. Fred. Hoffman asserts, upon the authority of exacter experiments, that a pound averdupois of pure water will dissolve six ounces of salt; which is in the proportion of one part of salt to two and two thirds of water. See Hoffman *De salinis Hallens.* C. ii. & *Obs. phys. chem.* Lib ii. Obs. 17.

³ Dr. Petit, in his most ingenious discourse on the precipitation of common salt in refining of salt-petre, observes, that twenty four drachms of the water of the Seine made scalding hot (*très chaude*) dissolved about eight drachms and an half, or at most nine drachms of marine salt; and that none of this salt was precipitated from the water when cold, no not in the coldest winter during the time of the hardest frost; and that the same quantity of boiling water did not dissolve more than nine drachms and an half of sea salt.

But on the contrary, water of different degrees of heat according to the temperature of the air, at different seasons of the year, retained very different quantities of salt-petre dissolved therein. For he observed, that, during

F

whilst

whilst hot⁴. So that in the foregoing process it is necessary to continue the evaporation, until the water which keeps the salt dissolved is in a great manner exhaled.

5. BUT in the crytallization of vitriols, nitre, and other less soluble salts, they proceed in another way, and boil the solutions of these salts to a pellicle, or until the hot water is saturated with them. These solutions are then drawn out into proper vessels, and when cool are greatly overcharged with salt, most of which therefore shoots into crytals.

the winter season, in a hard frost, twenty four drachms of the water of the Seine only retained dissolved three drachms of nitre; but in summer the same quantity of water of the same temperature with the external air dissolved ten drachms of nitre; and above seventy drachms of nitre might be dissolved in the same quantity of water made boiling hot.

In all these experiments the quantity of salts dissolved was somewhat different according as the water of the Seine contained more or less of a certain subtile earth, which he calls *Terre fine bolaire*. See the said discourse in the *Memoires de l'Acad Royal des Scien. pour l'Ann. 1729*.

⁴ If nine drachms of salt may be dissolved in a certain quantity of cold water, and only nine drachms and an half in the same quantity of boiling water, then a fully saturated brine of the heat of boiling water will, when cold, only let fall the nineteenth part of the salt it contains, if no water exhales from it while it is cooling.

6. IN

6. IN the process of boiling sea-salt great errors are often committed by continuing the evaporation too long, and so reducing a considerable quantity of the salts of the bittern into a solid form, along with the marine salt.

7. THE crystals of salt made by the foregoing process are most of them broken during the coction, and concreted together into irregular clusters or grains, from which it is difficult to determine the natural figure of the crystals of common salt.

8. BUT when, by a very gentle exhalation of water from common salt, it is suffered to shoot into its true form, its crystals are found of a cubical figure, of various sizes; and many of these smaller crystals are united together into hollow pyramids with a square base. These pyramids are truncated, being not finished at the top, but having there fixed a cube of salt of a more than ordinary bigness ⁵.

⁵ The salt-petre boilers, who in France preserve for domestic uses the common salt, which they extract in refining of nitre, observe, that during the time that the common salt precipitates from their lixivium, it ought to be boiled as gently as possible in order to have large and beautiful grains of common salt. For by this gentle coction, say they, the grain forms better, and is

9. IT ought also to be remarked, that, in the foregoing process, most of the saline crystals are formed nigh the surface of the brine, from whence the water is evaporated.

10. A SLOW and gentle evaporation of the water gives the salt liberty to form into large grains.

11. BUT violent and hasty boiling breaks the tender crystals of salt and makes the grain small.

12. The salt is also made of a small grain by stirring the brine about during the granulation⁶.

13. IF the evaporation be slowly performed, the saline crystals concrete into larger clusters, the longer they remain in the pan.

14. THOSE therefore, who would have salt of a large grain, must evaporate the brine very gently, while the salt is forming; and must suffer it to lie a long while in the pan, and must not draw it out until it all be formed.

better nourished. For then the grains are not bruised so violently against each other, and against the sides of the cauldron, as when the lixivium is made to boil more briskly. See the above mentioned discourse of Dr. Petit.

⁶ See *Ph. Transf. Abr.* by Lowthorp, vol. II. p. 358.

15. BUT those who desire to have their salt of a small grain, boil it pretty hastily, and draw it out of the brine as soon as a considerable quantity of it is fallen to the bottom of the pan, often drawing the pan five or six times during the time that the salt is forming; as will be explained hereafter in treating of the method of preparing basket salt.

16. THE salt made by a gentle evaporation of the water is not only of a larger grain, but also firmer and clearer, and of a more sharp and pungent taste than that which is made with hasty fires.

17. MOREOVER, the salt boilers unanimously agree, that much of their salt is wasted, when violent fires are used towards the end of the process, whilst the salt is forming, which they call the time of salting; so that when they boil violently at that time, they do not obtain so much salt, as when they use more slow and gentle fires⁷.

18. THEY also observe, that, when violent fires are used during the time of salting, the quantity of bittern is considerably greater than when gentle fires are applied.

⁷ This is confirmed by Dr. Plot, Dr. Hoffman and many others.

19. FURTHERMORE, when they use too hasty fires, large quantities of salt often adhere to the bottom of the pan; and the operators then say that the salt is burnt.

20. THE salt which thus adheres to the pan, and all salt grained with violent fires, is found unfit for preserving provisions. Such salt will not endure to be long exposed to the open air, but greedily imbibes the aqueous moisture, and with it runs into brine; for which reason, the operators say, that it is not well cleared from the fresh⁸.

THE inconvenience of quick fires is fully proved by the practice of the Cheshire salt-boilers; who, about a hundred years ago, made use of pans which only held about forty eight gallons of brine, and afterwards pans, which held twice that quantity, being somewhat more than a yard square and six inches deep⁹, and so hurried on their work that in the space of two hours they usually boiled one of these pans of brine into salt¹⁰.

⁸ The salt found adhering to the bottom of the pans at the Droitwich salt works, and there called clod salt, was probably salt thus burnt by hasty fires; and was found unfit for preserving beef.

⁹ See a representation of these pans with their furnaces and the hot houses behind them, Plate VI. Fig. 1.

¹⁰ See Dr. William Jackson's account of the method

But the salt made in this hasty manner was extremely weak, and of a small loose grain, and quickly grew moist, though dried in hot houses, and was therefore only made for present sale¹¹. I am well informed, that afterwards they made their salt pans gradually larger, until they held about eight hundred gallons; which is the common size of the pans now used in Cheshire: And in these pans, within the memory of several now living, they finished their process in twelve hours; and every week reduced twelve pans full of brine into salt. They found that the salt thus made was greatly preferable to that which they had made before with more hasty fires, but was still too weak for curing provisions for sea service. Of late years therefore they have proceeded in a more leisurely way, and only work out six pans of brine in the week, emptying their pan only once in twenty four hours. And since they fell into this method, their salt is much stronger, and more durable in the air than heretofore; being esteem-

of making salt at Nantwich in Cheshire, *Ph. Tr. abb.* by Lowthorp, vol. ii. p. 354, 355.

¹¹ See Dr. Thomas Rastel's character of this salt, *Ph. Tr. abb.* vol. ii. p. 358, 359.

ed equal in goodness to most kinds of white salt now made; and the demand for it is very greatly increased. In making a kind of salt called shivery salt, they use yet more gentle fires, and the process continues a longer time than ordinary, as will be hereafter more fully explained. And the salt, thus made, is of a larger and firmer grain, and is also stronger than any other kind of salt prepared by them.

C H A P. II. S E C T. III.

Memoirs for an Analysis of sea water.

FR O M the foregoing process it appears that sea water, besides common salt, contains several other ingredients; some of which in this process, are separated before the common salt falls; and others remain in the bittern, after all the salt is extracted.

I. O F the first kind are the sand, mud, and other impurities, which by the violent motion of the waves are stirred up and mixed with sea water, and again subside in it, while it rests in the cistern; or else are entangled in the whites of eggs and other mixtures, with which it is clarified.

II. B E-

II. BESIDES those gross substances, sea water contains a glutinous matter of a much finer texture, which is intimately dissolved therein. This glutinous matter, in the foregoing process, is probably separated from sea water by clarification. If we may give credit to Count Marfilli, it is of so light and subtile a nature, as to arise with sea water when distilled in a sand heat¹; and if so, may be mixed in rain water, and may greatly promote the growth and nourishment of plants²; to which use (as Dr. Woodward and others have observed) a green slimy substance that settles in rain water is in a peculiar manner adapted. This viscous matter of sea water seems earthy, saline, and oleagenous. It is this in stormy weather, when the waves rage and roar that forms a thick froth on the surface of the sea. To this viscous part is chiefly owing the putrefaction of sea water when suffered to stagnate³; by which pu-

¹ See his *Histoire physique de la mer*, Partie ii. p. 26.

² The antients therefore might have some reason for feigning that Venus sprang from the foam of the sea. Of whom Lucretius sings,

Quæ, quoniam rerum naturam sola gubernas,
Nec sine te quicquam dias in luminis oras
Exoritur, neque fit lætum, neque amabile quicquam.

³ Of the putrefaction of sea water when kept
trefaction

trefaction this slimy matter is so attenuated, that its texture is destroyed and part of it flies off in fetid exhalations, which are probably inflammable and permanently elastic; for it hath been observed, that the water of the Thames and other rivers generate an inflammable air during their putrefaction in long voyages. The more gross and earthy

in vessels, see the reverend Dr. Hales's *Phil. experiments*.

And that the whole mass of sea water is subject to corrupt, when suffered to stagnate, Mr. Boyle hath given us the following instances, "A navigator of my acquaintance, having often sailed in the Indian and African seas, told me that being once, though it was in the month of March becalmed in a place for twelve or fourteen days, the sea, for want of motion, and by reason of the heat began to stink; so that he thinks if the calm had continued much longer, the stench would have poisoned him. They were freed from it, as soon as the wind began to agitate the water, which also drove away shoals of the sea tortoises and a sort of fish that before lay basking on the top of the water."

And Sir John Hawkins takes notice; that "were it
 " not for the moving of the sea by the force of winds,
 " tides, and currents, it would corrupt all the world. The
 " experience I saw, says he, in the year 1590, lying with a
 " fleet about the islands of Azores, almost six months, the
 " greatest part of the time we were becalmed; with
 " which all the sea became so replenished with several
 " sorts of gellies, and forms of serpents, adders, and snakes,
 " as seemed wonderful; some green, some black, some
 " yellow, some white, some of divers colours, and
 " many of them had life; and some there were a yard
 " and an half, and two yards long, which had not I
 parts

parts of this viscuous matter, after its texture hath been thus broken by the putrid fermentation, subside in the sea water (and as the reverend Dr. Hales hath observed) fall to the bottom of the vessel in a dirty sediment.

III. BESIDES this viscous matter, sea water probably holds an earthy substance so very light and subtile that in the foregoing process it is elevated along with the watery vapours ; as there seems reason to conjecture from a white subtile earth, which I have observed adhering to the walls of several boiling-houses. And although it may seem absurd to talk of a volatile earth ; yet certain it is, that several substances known to chemists by the name of saline earths, are raised from certain bodies by their effervescent motions, or by the force of fire. Such are those volatile fumes that arise from quick lime when water is poured upon it ; and such is

“ seen, I could hardly have belived. And hereof are
 “ witnesses all the company of the ships, which were
 “ then present ; so that hardly a man could draw a
 “ bucket of water clear of some corruption. In which
 “ voyage towards the end thereof many of every ship fell
 “ sick of this disease, and began to die apace ; but that
 “ the speedy passage into our country was a remedy for
 “ the crazed, and a preservative for those that were not
 “ touched.” See Boyle on the *Saltiness of the sea*.

the

the subtile alkaline earth of lime water, which arises with it in destillation ⁴.

BUT we are more certain of the presence of another kind of earth in sea water, which in the foregoing process is obtained from it in very considerable quantities. This earth, to which the salt boilers have given the name of scratch ⁵, separates from the brine before the salt begins to form in it; and is either taken out in the scratch pans in the form of a white powder, or else adheres to the bottom, and sides of the salt pan in a hard stoney incrustation. This earth may also be probably separated from sea water by congelation. At least, I have found that Bristol water, frozen into ice and afterwards thawed, deposits a white calcarious sediment, very

⁴ I was informed by a gentleman of great judgment and veracity, who superintends several large collieries, that when he boiled water which sprang out of a bed of free stone in the boiler of a fire engine, the cylinder, into which the watery vapours arose, was often so filled with a stony powder, that the piston of the engine could not move in it, until the powder was cleansed out; for which reason he was obliged to supply the engine with other water.

⁵ By Dr. Collins in his discourse on salt and Fisheries, it is called stone powder: By Dr. Lister *de font. Med. Angliæ* Arena alba, and lapis albus: By Dr. Fred. Hoffman, Pulvis candidus. And by the same, most aptly, Succus maris, Salino-terreus, calciformis.

much resembling the scratch of sea water. The petrifying water of Knareborough being in like manner froze, doth also part with its stony matter. These earthy particles are not separated from sea water in the same state in which they were dissolved therein; for when by coction a large quantity of the water is evaporated and thereby these particles are brought into closer contact, they strongly attract each other, and remain no longer suspended in the water; but firmly concrete into large clusters; which cannot again be dissolved in water⁶, unless they be first disunited by art, and reduced into such minute particles as they existed in before their union.

THAT these particles are extremely small and minute while dissolved in water, appears from their passing with it through the filtre⁷; so that, during their dissolution, they seem sufficiently fine and subtile to enter the vessels of animals and vegetables. And in-

⁶ Hence appears the reason, why, if the dry remainder extracted from sea water be again added to the water distilled from it, it is not of the same specific gravity it was of before distillation; each pound of it, according to count Marfilli, wanting a scruple of its former weight.

⁷ See *Exp. made by Dr. Plot, Nat. Hist. of Staffordshire*, Chap. ii. § 109, 110.

deed this subtile earth appears to be a very necessary ingredient in sea water, serving for the nourishment of marine plants, and also of many fish, more particularly of the testaceous and crustaceous kinds; to whose coverings, as well as to corals and several other stoney plants, it hath a great affinity.

By a subtile earth of this kind may be produced several stony incrustations, and petrefactions of moss, wood, and other vegetable substances; also stalactites, and other stony concretions⁸.

THIS earth is capable of being dissolved by water in very considerable quantities. The water of the salt springs of Weston in Staffordshire contains about a thirty sixth part of its whole weight of this earth; which is nearly in the same proportion, in which common salt is usually found dissolved in sea water⁹.

THE great solubility of this earth in water, shews that it nearly approaches to the nature of salts. It is even found to enter the

⁸ See an instance of this kind in the following chapter from Dr. Scheuchzer's *Account of the Saltworks at Bevioux in Switzerland*.

⁹ See Dr. Plot's *Nat. Hist. of Staffordshire*, C. ii. § 104.

composition of perfect salts. For being long exposed to the open air, it imbibes the aerial vitriolic acid, and with it is converted into a neutral salt, which Dr. Lister ranks amongst the species of his calcarious nitre¹⁰. This salt, in taste, very nearly resembles the bitter purging salt of Epsom waters; as I experienced in some of it which I found germinated on stone scratch, that had been kept by me four or five years.

FROM the foregoing observations, this earth appears to have an alkaline quality; which is further confirmed by other experiments. For when reduced to powder, and mixed with syrup of violets diluted with water, it instantly turns the mixture from a blue to a green colour. I have known the glass makers substitute it for kelp in their composition for making glass. And it is well known that kelp, or the ashes of the herb kali, owes its quality of vitrifying with sand, chiefly to the alkaline salt which it contains. This earth, being mixed with clay, makes a strong cement, which the salt boilers use for repairing their furnaces.

¹⁰ In his treatise *De fontib. medicat. Angliæ*, L. i. p 36.

It is well known that the shells of the sea fish (which seem to be nourished chiefly by this subtile earth) partake of an alkaline nature, and may by calcination be reduced into quicklime ; to which, we may conjecture from the preceeding experiments, that this earth bears some affinity. And having purposely made the trial, I found that stone-scratch after calcination by a violent heat in an air furnace, fell into powder in the open air, and had other properties of quick lime.

THE marine scratch therefore seems to deserve the title of a saline calcarious earth. But I am far from thinking that all earths which come under that general denomination, are exactly of the same nature, and agree in all their properties. On the contrary it is more reasonable to believe that there are several kinds of calcarious earth, which are more or less subtile, more or less corrosive, and have other specific differences ; one kind bearing a resemblance to chalk, another to limestone, a third to quick lime, and a fourth to alabaster ; one kind, with the vitriolic acid composing alum, another with the same acid Epsom-salt, and others with the same acid
other

other kinds of calcarious salts. So that these earths ought not to be all confounded together, but each kind distinguished by its private properties.

THE magnesia alba, so justly celebrated in Germany for its mild purgative anti-acid virtues, is a kind of calcarious earth, very nearly related to the scratch of sea water; being with acids converted into a bitter purging salt, which is not the case with quicklime, crabs eyes, and several other alkaline earths. Whether the marine scratch will have the same effects with the magnesia upon the human body, must be determined by future trials. It is certain that several mineral waters owe their purging qualities not to any perfect salt with which they are impregnated; but to a subtile calcarious earth, as Dr. Fred. Hoffman hath fully proved in the waters of the Caroline baths in Germany.

IN the examination of mineral waters; their earthy ingredients, which are too often considered as inert, and without efficacy, do therefore require a nicer attention. We find that calcined sponge, which is a marine production and holds a calcarious earth, is a useful remedy in scrophulous disorders; and the salutary effects, which several mineral waters,

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and which sea water hath also been observed to produce in those distempers, may be attributed, in part at least, to the calcarious earth which they contain. There are many purging waters, as those of Epsom and Scarborough, which agree with sea water in that they hold a calcarious earth, together with a muriatic and a calcarious salt. But how far the earths of these waters agree with the marine scratch, and in what they differ from it, and from each other, can only be determined by proper experiments.

IV. THE ingredient of sea water, which, in the foregoing process, falls next under our consideration, is common salt. And the quantity of this salt contained in sea water, is found very different in different parts of the ocean, and even in the same parts at different times.

THE Baltic sea, receiving more fresh water than exhales from it, is but weakly impregnated with salt. The water of the British and German seas, is considerably saltier than that of the Baltic; and the water of the Mediterranean (from which more fresh water is thought to exhale than falls into it) is esteemed saltier than that of the British or German seas; and the water of other seas may probably contain a larger proportion of

salt than that of the Mediterranean, as hath been conjectured of the water on the coast of Mosambique¹¹.

A physician, to whom Mr. Boyle recommended the trial, affirmed, that in sailing from England to the West Indies, he found the water of the ocean to increase in gravity, the nearer he came to the line, till he arrived at a certain degree of latitude (as he thought) about the thirtieth; after which, it seemed to retain the same specific gravity 'till he came to Barbadoes or Jamaica¹². But the authority of this gentleman does not seem of such weight as that of father Feuillée, who, in passing through the streights of Gibraltar towards America, observed the water to diminish in weight in proportion as he approached the line¹³.

THIS difference in the saltiness of the sea in different places, seems to proceed from various causes. As, from the quantity of vapours exhaling from it, which is very different in different places. Also from the quantity of fresh water received into certain

¹¹ See Boyle *on the Saltiness of the sea*, abb. by Dr. Shaw, vol. iii. p. 224.

¹² See the same work, p. 223.

¹³ See *Memoires of the Royal Acad. for the year 1711*.

parts of it, in rains, or from the mouths of rivers¹⁴. Or from beds of fossil salt, which may be seated in several places at the bottom of the ocean¹⁵. Or from the salt waters of springs and rivers which are discharged into it, in certain places¹⁶.

¹⁴ Count Marfilli found the water of the Archipelago taken up nigh Smyrna considerably heavier than that of the Euxine; and that of the channel of Constantinople, or the Thracian Bosphorus, in some places heavier, in others lighter than that of the Euxine according as it was taken up nearer to, or farther from the mouths of rivers. See his *Observations made on the Bosphorus of France*.

Such vast quantities of water are discharged from the Riv della Plata in Brazil, that fresh water may be taken up in the ocean fifteen miles from the mouth of that river. The same is reported of the river Quire in Africa.

On the coast of Malabar, during the rainy season, so much water falls in rains, and is discharged from rivers, that the sea water in several parts nigh land becomes almost sweet and potable. Du Hamel Phil. Burgund. Cap. *De maris falsedine*.

¹⁵ As nigh the isle of Ormus. And in deep parts of the ocean, where the water is not disturbed, the salt may dissolve very slowly, as all the water adjoining to the salt rocks will be fully satiated with it.

¹⁶ Most of the rivers in the kingdoms of Algiers and Tunis are impregnated with salt; and doubtless contribute to the extraordinary saltness of the Mediterranean waters. Herrera informs us, that the Rio de la sal in Chili is so extremely salt, that the parts of horses wet with it, as soon as they are dry, appear incrusted over

THE reverend Dr. Hales, by a gentle evaporation of sea water taken up near the Buoy at the Nore at the mouth of the Thames obtained from it $\frac{1}{17}$ 2 of its whole weight of salt. And from the Mediterranean water taken up thirty leagues north of the isle of Malta $\frac{1}{17}$ 3 of salt¹⁷. Count Marfilli found that water taken from the surface of the sea in the gulf of Lyons, yielded by a gentle distillation only $\frac{1}{32}$ of its whole weight of salt; whilst that which was taken up at the same time and place from a great depth yielded $\frac{1}{15}$ of salt; and hence concludes that sea water is much saltier in profound parts of the ocean, than at the surface¹⁸. This indeed may be the case in the gulf of Lyons nigh the mouths of the Rhone; and also nigh the mouths of other great rivers, whence the fresh water flowing out, is mixed chiefly with the superficial sea water, whilst that in deep parts remains undisturbed. But this rule does not hold universally true in all places; for Mr. Boyle found the water of the British channel equally heavy at the sur-

with salt; and that the salt lies concentered on the borders of the river.

¹⁷ See his *Ph. Experiments on distilled sea water*.

¹⁸ See his *Histoire Phys. de la Mer*.

face and at the bottom. And at some places (as in the Pacific ocean) where large quantities of water arise in vapours, and very little falls again in rains, or is received from rivers, the superficial water may probably be much saltier than that which remains undisturbed at the bottom.

It ought to be remarked, that in the foregoing experiments of extracting the salt from a certain quantity of sea water, all the dry remainder hath usually been taken for common salt; although it is not a pure marine salt, but hath several other ingredients mixed with it, particularly a considerable portion of a calcarious earth, and also the salts of the bittern. It likewise ever contains a considerable portion of aqueous moisture, which is more or less according as the heat was continued a longer or a shorter time after the impure salt or remainder appeared in a dry form. Mr. Boyle having evaporated water taken up in the British channel to a dryness, found the dry remainder, which he calls salt, to weigh near $\frac{1}{30}$ of the whole water; but after heating and drying it well in a crucible, it only weighed $\frac{1}{37}$ of the water used¹⁹. The

¹⁹ See his *Treatise on the saltiness of the sea*.

quantity of dry remainder will also be considerably less when the water is evaporated from it with a violent heat, than when only a gentle heat is applied. So that from these experiments, in which a certain quantity of sea water is evaporated, and the impure salt remaining weighed ; nothing certain can be determined of the true quantity of common salt which sea water doth contain.

As true an estimate may probably be made from the experiments of the salt boilers. Those of them who have been most accurate in their trials affirm that in Solway Firth on the coasts of Cumberland, they commonly obtain a pound of pure marine salt from forty pounds of sea water ; and after the greatest draughts, seldom more than a pound of salt from thirty five pounds of water ; but, after heavy rains and great land-floods, the sea water is there so weakened, that it does not afford above a fiftieth part of its weight of pure salt. The Newcastle salt boilers assert, that, on the coasts of Northumberland and Durham, from thirty tuns of sea water, they usually extract a tun of salt ; but in this calculation it is probable that they do not estimate the quantity of water by weight, but by measure.

FROM

FROM all these observations, it may be concluded in general that sea water taken up on the British coasts, at some distance from the mouths of rivers, seldom holds more than $\frac{1}{30}$, or less than $\frac{1}{50}$ of common salt. And that the water of some seas, as of the Baltic is impregnated with less salt, and that of the other seas with more salt, than the water taken up on the coasts of Great Britain.

BESIDES common salt, sea water contains several other salts which are found in the bitter that remains in the pan after all the marine salt is extracted.

V. FOR first it contains a bitter purging salt, known better to many by the name of Epsom salt; having first been extracted for medical uses from the waters of Epsom, and afterwards from those of Dulwich, Shooters-hill in Kent, and from other purging waters in several parts of England. But all this salt now vended, is prepared entirely from the marine bitter, at the salt works nigh Newcastle, and at those at Lemington and other parts of Hampshire. To this salt seems chiefly owing the bitter taste of sea water, although the opinion hath generally prevailed that this taste proceeded from
from

from bitumen²⁰. From the experiments made on this salt, it seems composed of a vitriolic acid, united to a large quantity of a

²⁰ I readily grant that there are several bituminous bodies, which in various parts are mingled with the marine waters. Thus Mr. Boyle informs us that the Barbadoes tar is carried in considerable quantities from rocks into the sea. And count Marfilli observed spiral filaments to arise in the sea Marmora nigh Constantinople, which concentered into bitumen exactly of the same kind with that which he had observed to flow from a bituminous fountain in the isle of Zant. On some of the coasts of Italy they skim an oil like petrolium from the surface of the sea. And ambergreece may probably be a bituminous substance cast up from the ocean. Many parts of the sea are also frequently covered with a subtile pinguous substance, which shines and gives light in the night. These unctuous substances may impart various properties to sea water in places where they abound; but none of them are found constantly mixed with the marine water; nor does it appear that they are capable of giving it its bitter taste; so that this taste seems to proceed almost entirely from the bitter purging salt, every where present in sea water. Count Marfilli hath indeed proved that a spirit distilled from pit coal will give water a bitter taste, but he hath not proved that sea water is impregnated with such a spirit; on the contrary distilled sea water hath no bitter taste, as Dr. Hales hath well remarked, and therefore the marine waters are not impregnated with such a volatile spirit, but owe their bitterness to a fixed principle. And that pit coal can scarce impregnate water with such a fixed principle, appears from examining the water which flows from large strata of this mineral; which water is commonly impregnated with iron, but hath never been observed to have a bitter taste.

calcarious

calcarious earth ; and may therefore be called a vitriolic calcarious salt ²¹.

VI. ANOTHER salt is found in bittern, which may be called a muriatic calcarious salt ; its acid principle being spirit of salt, which is loaded with a large quantity of an earthy substance most nearly related to quicklime. For this salt, being exposed to the fire, doth not part with its acid spirit until its saline earth is reduced to a calx more sharp and corrosive than quicklime itself. This salt remains in the bittern after the bitter purging salt is extracted from it ; and, though a neutral salt, can scarce be brought into crystals, but by the force of fire may be reduced to a solid form ; which yet it retains with difficulty ; for of all the coagulable salts, it most greedily imbibes the aërial humidity, and with it most readily runs per deliquium ²², This salt, though little known,

²¹ Of this and the following salt see an account published in the *Trans. of the Royal Society* N° 377, 378. by Mr. Brown the Chemist.

Also Dr. Hoffman's *Obs. Phys. Chem. De Lixivio a sale relicto*.

²² The great reluctancy which this salt discovers to be reduced to a solid form, seems also to shew the near affinity between its earth and quicklime. For Stahl informs us, that those who putrify nitre find no better me-

is now applied to some profitable uses ²³, and might be applied to other uses medical as well as œconomical ; which are left to the discovery of the ingenious.

VII. BESIDES these calcarious salts, the marine bittern contains a considerable portion of a fixed mineral alcali, as may be judged from its turning syrup of violets of a green colour. Whether this salt exists in sea water before its coction, seems difficult to determine, as will more fully appear from some experiments hereafter to be related. It is however certain, that sea water partakes of an alkaline quality ; for though the colour of syrup of violets is not readily changed by it, yet the blue tincture of flowers of Cyanus (which more quickly turns red with acids and green with alcalies than syrup of violets) being mixed with sea water, the mixture in about twelve hours becomes of a pale green, as I have frequently experienced.

rhod of freeing it from marine salt than by mixing it with lime water ; which uniting to the acid of sea salt, therewith forms a saline liquor, which will not shoot into crystals.

²³ Amongst those uses, I do not reckon one to which some have applied it ; counterfeiting therewith the blood of the Popish saint Januarius ; which, as many believe, liquefies at the approach of the head of that saint.

But

But whether this change of colour proceeds from the calcarious earth or from a small portion of an alkaline salt contained in sea water, must be determined by future experiments. It however seems strange that so alkaline a substance as scratch, which, when reduced to powder, so readily turns these mixtures green, should yet have so little effect upon them when more intimately dissolved in sea water.

THE ingredients of sea water already mentioned are the chief which fall under the cognisance of the marine salt-boiler. Although it is also impregated with the feeds, sperm, and excrements of innumerable kinds of plants and animals, and the tinctures which those plants and animals impart to it, while they corrupt and dissolve therein. These, together with diverse saline and sulphureous bodies not here mentioned, will necessarily fall under the consideration of those, who shall hereafter attempt to oblige the world with a natural history of the marine waters ²⁴. To whom, as well as to the

²⁴ It may indeed seem strange, that, after the learned have spent so much time and study in searching into the nature of mineral waters, the water of the ocean, that grand fountain of fountains, which nou-
inqui-

inquisitive salt-boiler, the imperfect memoirs here given may not be wholly un-
useful.

C H A P. III. S E C T. I.

The method of boiling brine salt.

OF salt boiled from the waters of wells and springs, which we call brine salt, great quantities are daily made and used; especially in countries remote from the sea, as in the inland parts of Germany, in Hungary, and Switzerland, in which and in many other countries, springs of salt water are very common ¹.

fishes and supports such an infinite variety of creatures; which hath such remarkable effects upon the human body, which diffuses its influence over the whole sublunary creation, and is so wonderfully adapted to the various ends of the all-wise creator; should nevertheless remain almost totally neglected by them.

¹ Amongst the most remarkable salt springs, may be ranked those of Salins in Franché Compté; art seeming to vie with nature, in contributing to render them most surprizing. These springs are situated in deep caves, which in the greater work (for there are two in that City) are about four hundred feet in length, and fifty or sixty in breadth. Into these caves (of the greater work) they descend by a stone stair-case of forty one steps, and then by wood-stairs of twenty steps. At the bottom of these stairs, is a cave with an arched roof.

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In several parts of England, as in Somersetshire, Cumberland, Westmoreland, Dur-

This first cave or vault is forty feet long, and thirty two and an half broad; and in it are six springs of salt water, and two of fresh water, all which gush out of the same rock, within the space of fourteen feet. From this cave or vault they go into others, supported in the middle by a row of thick pillars, on which double arches rest. They then pass through two gates into a spacious vault thirty five feet high, and supported nigh the enterance by four strong pillars placed square ways, and in the middle space within these pillars is a large bason, into which the waters of the several salt springs are collected. In the same vault beyond these pillars are four others, placed in a row supporting different arches of sixty feet in length, and forty eight feet in breadth; beyond which there is an irregular space sixty three feet long, in which are six or seven springs of salt water, and ten or twelve of fresh.

The salt waters of these springs, and of the six springs before mentioned, are kept separate from the fresh water; and are all conveyed through gutters into the large bason before mentioned. From this bason they are drawn out, by an engine called the wheel and buckets, into four large stone basons or reservoirs, one of which holds fifteen thousand hogsheads, and the other three together twenty five thousand hogsheads. From these reservoirs they are drawn off, as occasion requires, into smaller cisterns placed nigh the boiling houses (the waters contained in the several basons, (as they are drawn from the springs at different times, and are of unequal strength) are mixed together in such proportions in the cisterns, that each pound yields about three ounces of salt. The water of the fresh springs is also collected together in the caves, into a bason prepared to receive it, and is raised by means of a crane to the level of a little
ham,

ham, and Yorkshire, many salt springs have been discovered; but they are either weak, or situated where fuel is scarce; and for these and other reasons, are not wrought for salt.

BUT in other parts of England there are many rich and valuable salt-springs, from which great store of salt is daily extracted. Of these some are situated in Staffordshire, and several in Lancashire; but the chief are those at Droitwich in Worcestershire, and Northwich in Cheshire, about which last mentioned place, there are many rich mines of fossil salt; above and beneath the beds of which, the brine is commonly found. And when, as it frequently hap-

brook, into which it runs through a subterraneous conduit. For a farther account of these springs and saltworks, See the *General System of Geography* lately published at London vol. i. p. 346.

The salt springs in England and other countries are, most of them, wells or pits of different depths, in some of which the brine stagnates, and never rises to the top, but flows out at the top of other wells, when it is not drawn out for use. See a Description of the salt springs at Hall in Saxony in Hoffman's *Treatise Des Salinis Hallens*: Also of several in England in the *Ph. Tr. Ab.* vol. ii.

At some places, as at Schower in upper Hungary, the water which they draw from their salt mines, being a very strong brine, they boil into salt.

pens,

pens, the salt is in a good measure exhausted, and the brine is so weak, that it can no longer be wrought to profit; they then sink pits in other likely places, and seldom fail of meeting with strong brine. There are also many brine springs in other parts of the last mentioned county, as at Middlewich and Nantwich², at the last of which places the pits are of a very ancient standing, and are said to have been wrought in the time of the Roman government.

THE brine of these springs is observed to differ greatly in strength and purity; some kind of brine affording a much larger quantity of salt, and fitter for most uses, than that which is extracted from other fountains.

THAT brine may be esteemed the strongest of which a pound averdupoize yields six ounces of pure salt. The brine of Barton in Lancashire, and of several pits at Northwich is nearly of this strength, being almost fully saturated with salt. That of Droit-

² Most of which are situated nigh the river *Weewer*.
 “Sink on either side the said river for many miles,
 “and you will scarce miss of brine.” *Lister’s Obs. on the midland salt springs. Ph. Tr. Abb.* by Lowthorp. vol. p. 361.

wich, Upwich and Middlewich contains about a quarter of salt. The brine of other springs at Northwich and Nantwich yields about a sixth, and that of Weston in Staffordshire only about a ninth part of salt: In England they seldom boil a weaker brine alone, than that last mentioned; but in some parts of Germany, where salt is very scarce, they extract it from water which is more weakly impregnated with it, than the marine waters.

IT hath been observed at several salt springs, that the brine is much stronger at the bottom of the pits than nigh the surface; also in dry weather than in wet; and when the pits are constantly drawn, than when little brine is drawn out of them. But in some springs, as in those of Salins in Franche-Comté, the brine is not only found more plentiful, but also stronger after wet, than after dry weather.

BESIDES common salt, the brine of most springs is impregnated with many other ingredients, with the nature and properties of which the brine salt-boiler ought to be acquainted, as by that means he will be enabled to exercise his art with greater dexterity and judgment.

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AND

AND first, the brine of most salt wells, and particularly the English brine, hath something of a sulphureous principle mixed with it, as may be concluded from its fetid sulphureous smell, which quickly goes off with boiling³. This sulphureous principle gives to the brine impregnated with it, an intestine putrifying motion; and makes it quickly corrupt the flesh of animals steeped therein.

2. THE brine of many of the English salt springs turns atramentous with galls⁴, and hath mixed with it an ochery substance,

³ “ The brine of the Droitwich pits (as Dr. Lister assures us) stinks like rotten eggs, and will, if flesh be pickled with it, make it stink in twelve hours. And yet (adds he) the salt that is boiled of these pits is accounted the very best inland salt of all England, and, I believe, as good as any in the world.” *Ph. Transf. abr.* by Lōwthorp, vol. ii. p. 362.

It hath since been found that the Droitwich brine, after it is boiled and clarified, is an excellent pickle for curing beef, and other domestic uses.

In the level or gallery, through which the salt water is conveyed to the salterns at Bevieux in the Pais de Vaux, Dr. Scheuchzer observed several veins of virgin sulphur. Several of the miners, in digging the said level, were killed by explosions of the fulminating damp.

⁴ This Dr. Lister observes of the brines of Nantwich, Middlewich, Northwich, Weston, and Droitwich.

Dr. Leigh, in his *Nat. Hist. of Lancashire and Cheshire*, affirms, that there are several salt springs in those counties, the brine of which is not altered by galls.

which

which separates from it, and subsides, when the brine is suffered to stand in an open vessel ; or falls to the bottom of the salt pan as soon as the brine begins to boil.

3. BRINE hath also commonly mixed with it a large quantity of a light calcarious earth, or scratch, exactly resembling that of sea water. It abounds in the Cheshire brine, and in all their salterns they collect it into scratch pans ; and once a week, or oftener, pick off the stoney crust which adheres to their salt pans. It is also found in the brine of the German salt springs. And it is probably the peculiar excellency of the Droitwich brine to be intirely free from any mixture of this earth ^s.

^s Dr. Scheuchzer gives the following relation of the manner of depurating the brine from part of this earth at the works at Roche, or Bevieux. “ Antequam vero in
 “ ipsas cortinas, quæ ferreæ sunt, admittitur (aqua salsa)
 “ depuratur in alveo prælongo ducentorum forte pedum,
 “ decem circiter lato, tecto columnis insistente,
 “ a pluvix miscela munito : hic ordine suspen-
 “ duntur fasciculi straminum octo circiter pedum;
 “ quibus aqua salsa ex alveo aspersa affigit particulas
 “ terreas, quæ sensim ad digiti fere crassitiem incrustant
 “ stramineos culmos, atque tunc rejiciuntur, ut novis fasci-
 “ culis stramineis suspendendis locum cedant. Adno-
 “ tari meretur, horum Stalactitarum vel Striarum arte-
 “ factarum non externa solum cylindricâ figurâ ita sæpe
 “ concreta, ut massa Stelechiten vel Stalactiten ramosum
 “ referat, sed præprimis structura interna veluti radiata
 “ radiis undique a peripheria ad centrum convergentibus

4. AT the bottom of several brine pits there is found a light black mud; which, when stirred up, infects the whole spring, like the scuttle fish, black. Some of the pits in Cheshire, which abound with this mud, are in boggy grounds, where the soil is a peat earth. The briners there frequently empty these pits, in order to cleanse them from this mud. At Hall in Saxony, they fix bundles of rods in the middle of their pits; through which the brine passing, this mud is intercepted, as by a strainer.

5. THE brine of most springs is also imbued with various kinds of salts. In boiling the waters of the German salt springs there remains a ponderous liquor, which they call *Mutter soole*, or mother brine, resembling the marine bittern, but seeming to partake more of the muriatic calcarious, than bitter salt of sea water, as may be concluded from the experiments made thereon by Dr. Fred. Hoffman⁶. Most of the mineral waters of England, which are impregnated with bitter salt,

“ insignita, cui genesi ansam dedit æqualis undique
 “ partium terrearum ad stramen adhæsiō; materia ha-
 “ rum Striarum est coloris terrei fere vel flavescentis,
 “ substantiæ specularis, ut ipsorum Stalactitarum.”
Iter Alpinum septimum.

⁶ *Obs. Phys. Chem.* Lib. ii. Obs. xviii.

do with it hold plenty of common salt. And we are assured by Dr. Leigh, that those two salts are also found together dissolved in the brine of Cheshire⁷.

6. HOFFMAN informs us, that several of the salt springs in Germany are impregnated with a mineral alcali; and many of the English brine springs seem also to partake of the same, as will be more fully discussed hereafter.

THE antient methods of boiling brine into salt in Cheshire and Worcestershire are accurately described in the acts of the Royal Society; and the method formerly used in Staffordshire is related in Dr. Robert Plot's *Natural history* of that county, to which accounts the reader is referred. The method now practised in those counties, agrees pretty well with that used in Germany; and as it differs in several particulars from the method of boiling sea salt, before related, it is necessary here to give a short account of it.

THE brine being received from the well

⁷ “ Besides the marine salt, these springs do likewise “ contain the nitrum calcarium.” Leigh, *Nat. Hist. of Lancashire, Cheshire, &c.* p. 44. And in the following page and elsewhere he tells us, that by Nitrum Calcarium he means the bitter purging salt.

into the cistern, is from thence drawn, as occasion requires, into the salt pan. These pans are of the same form with those used in boiling sea salt; but less, usually holding about eight hundred gallons⁸; and in Cheshire are made of iron, but at Droitwich of lead, The salt pan being filled with brine, and the scratch pans placed at its corners, the fire is kindled, and some blood from the butchers is dissolved in a little of the brine, and mixed with that in the pan, in order to clarify it⁹. (An ounce of blood, it is said, will clarify eight hundred gallons of brine.) The brine, as soon as it boils, is skimmed; and afterwards suffered to boil violently, till the salt begins to form in it. The scratch is then all separated, and the fire being slackened, it is suffered to subside, and, when it hath all fallen into the scratch pans, they are then taken out of the

⁸ At Inn'thale in Tirol the iron pans, in which they boil their salt, are forty eight feet long, thirty four feet broad, and three feet deep.

At Salins they use iron pans of a round form, twenty eight feet in diameter, and fifteen inches deep. The practice of these foreigners is highly worthy the imitation of the English, as will be explained in another place.

⁹ At Droitwich, and some other places, they clarify their brine with whites of eggs.

salt pan. But when they boil brine of so great strength as to be almost fully saturated with salt, they cannot conveniently clarify it, because the salt begins to granulate before the brine boils; in that case, therefore, they mix no blood with it, but boil it briskly for a little time, till all the calcarious earth and ocher are separated; these mix with the salt then formed, and render it very impure; which is therefore raked out, and thrown away as useless. And this they call the first clearing of the pan ¹⁰.

IN either case, as soon as they have cleared the pan of scratch, and other impurities, and have brought the brine to such a state, that the salt begins to crystallize in it; they then usually mix with it ale, butter, and other additions, or seasonings, which they add, with a design either to correct some supposed faults of the brine, or to make the salt of a smaller grain, or for other purposes, of which it will be necessary to treat hereafter.

¹⁰ When the brine was weak, they formerly filled up the pan two or three times with new brine, as in preparing sea salt; but now they commonly heighten such weak brine with rock salt.

THESE seasonings being well mixed with the brine, they boil it very gently during the rest of the process, and when as much salt is formed as will fill two or three of their large wicker baskets, they then rake it to the side of the pan, and fill it out into the baskets¹¹; placing them over the leach-trough, that the leach-brine may drain into it from the salt. The salt taken out, they call a draught of salt, and the operation a clearing of the pan. And in this manner they draw the salt, and clear the pan five or six times in each process; leaving at last, only a few quarts of brine at the bottom of the pan, to keep it from burning. The whole process usually lasts about twenty four hours¹².

¹¹ These baskets, which are also called barrows, and usually contain about a bushel of salt, are of a conical figure, open at the base; see them rudely represented, together with the leach-troughs, hot-houses, &c. Plate VI. Fig. 1. and 2.

¹² And here it may be proper to take notice of Mr. Lowndes's laudable attempts for improving the English brine salt. And as he hath lately been induced by parliamentary encouragement to reveal his secret, I shall therefore here give his process in his own words; some of the advantages, as well as defects whereof, will be pointed out in the following sheets.

“ Let a Cheshire salt pan (which commonly contains about eight hundred gallons) be filled with brine, to

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THE falt, after it hath drained for an hour or two in the baskets over the leach-trough ; is removed into the hot house, behind their furnace, where it remains four or five hours, till thoroughly dried and is then taken out of

“ within about an inch of the top ; then make and light
 “ the fire ; and when the brine is just lukewarm, put in
 “ about an ounce of blood from the butcher’s, or the
 “ whites of two eggs : let the pan boil with all possible
 “ violence. As the scum rises, take it off : when the fresh
 “ or watery part is pretty well decreased, throw into the
 “ pan the third part of a pint of new ale, or that quantity
 “ of bottoms of malt drink. Upon the brine’s beginning
 “ to grain, throw into it the quantity of a small nutmeg
 “ of fresh butter ; and when the liquor has salted for about
 “ half an hour, that is, has produced a good deal of salt,
 “ draw the pan, in other words, take out the salt.

“ By this time the fire will be greatly abated, and so
 “ will the heat of the liquor. Let no more fuel be thrown
 “ on the fire ; but let the brine gently cool, till one can
 “ just bear to put one’s hand into it : keep the brine of
 “ that heat as near as possible ; and when it has worked
 “ for some time, and is beginning to grain, throw in the
 “ quantity of a small nutmeg of fresh butter, and, about
 “ two minutes after that, scatter throughout the pan, as
 “ equally as may be, an ounce and three quarters of clean
 “ common allum, pulverized very fine ; and then instantly,
 “ with the common iron scrape-pan, stir the brine very
 “ briskly, in every part of the pan for about a minute.
 “ Then let the pan settle and constantly feed the fire, so
 “ that the brine may never be quite scalding hot, nor
 “ near so cold as lukewarm : let the pan stand working
 “ thus for about three days and nights, and then draw it.

“ The brine remaining will by this time be so cold,
 “ that it will not work at all ; therefore fresh coals must
 “ be thrown upon the fire, and the brine must boil
 “ for about half an hour, but not near so violently as
 the

baskets, and laid up in the store house for sale¹³.

In all the English brine salt works, the liquor called leach brine, which drains from the salt in the baskets, or remains in the salt pan after the process is finished, is not thrown away as at the German salt works, and in the process of boiling sea salt ; but is

“ before the first drawing. Then, with the usual instru-
 “ ment, take out such salt as is beginning to fall (as
 “ they term it) and put it apart ; now let the pan settle
 “ and cool. When the brine becomes no hotter than
 “ one can just bear to put one’s hand into it, proceed
 “ in all respects as before ; only let the quantity of
 “ allow not exceed an ounce and a quarter. And in
 “ about eight and forty hours after draw the pan.”

This is Mr. Lowndes’s process ; only he afterwards directs cinders to be chiefly used in repairing the fires, the better to preserve an equal heat ; and by that means also proposes to save a considerable part of the expence of fuel ; asserting that “ at present cinders are so little
 “ valued in Cheshire, as generally to be thrown into
 “ the highways.” Mr. Lowndes informs us, that in a pan of the size directed by him to be used, there may be prepared at each process sixteen hundred pound of his salt, from the best brine in Cheshire ; and 1066 pounds from the ordinary brine of that country. Which, as the process continues above five days, is little more than five bushels and a half of salt every day, from the best brine, and a little above four bushels a day from the ordinary brine.

¹³ At Droitwich they make no use of hot houses for their large grained salt, but only let it drain in the barrows four or five hours, and then lay it up in their storehouses, which are lined on every side with boards, and have an inclining floor like drabs ; and with this treatment it becomes sufficiently dry.

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constantly mixed with the next pan full of brine, and with it boiled into salt.

BESIDES the common salt prepared, as before related, at most of the English brine works, they make a salt which they call shivery salt, being of a firmer and larger grain than that prepared by the foregoing process, and also stronger and more proper for preserving provisions. In preparing this salt, they begin to work on Saturday night, proceeding exactly as in the foregoing process, 'till the salt begins to form. But as they draw no salt on Sunday, they therefore only keep a very gentle fire under the pan all that day, and so grain the salt with a much milder heat than at other times; taknig out the shivery salt all at one draught early on Monday morning.

THEY have also another kind of salt, made up like sugar loaves, in small wicker baskets, and therefore called loaves of salt, or basket-salt; which is greatly esteemed for table use, being the whitest salt, and perfectly dry, and of the smallest grain¹⁴. In preparing this

¹⁴ At Salins they put the wet salt, which they draw from the bottoms of their pans, into wooden moulds, in which they dry it in stoves, and thus form it into cakes or loaves weighing three or four pounds.

salt, some use rosin ¹⁵ and other additions to break the grain, and make it small; and for the same purpose others boil the brine very briskly, or keep constantly stirring it, whilst the salt is forming. But the method most approved of in Cheshire, is to proceed exactly as related in the process for preparing common brine salt; and for basket salt to take the second and third draughts, which are esteemed the purest salt. These draughts they do not suffer to lie so long in the pan, as when they make salt of a larger grain, but take them out before the salt can concrete into large crystals; and by this means obtain a salt of a fine small grain. This salt they press down hard into small wicker baskets, and when it is sufficiently drained over the leach trough, remove it with the baskets into the hot house; and after it hath been there well dried, carry it into the store-house, and keep it in the baskets for sale.

¹⁵ As at the works at Droitwich.

C H A P. III. S E C T. II.

Of the additions, or seasonings used by salt-boilers.

THE salt boilers, and particularly those who prepare brine salt, have long been accustomed to make use of various substances which they call additions or seasonings, and mix with the brine while it is boiling, either when they first observe the salt begin to form, or else afterwards during the time of granulation.

THESE additions they use for various purposes. As first to make the salt grain better, or more quickly form into crystals. Secondly, to make it of a small fine grain. Thirdly, to make it of a large firm and hard grain, and less apt to imbibe the moisture of the air. Fourthly, to render it more pure. And lastly, to make it stronger and fitter for preserving provisions.

THESE ends may some of them be answered by the additions made use of ; but others, not ; or at least, might be better answered

swered by other means. So that several of these additions seem no way useful, but rather prejudicial. Neither is this to be wondered at ; since this business is too often left to unskilful operators, who will not easily be beat out of their old road ; or if they make any new trials, are wholly ignorant of the nature of the substances they use, and apply them at a venture, without being able to form any conjecture of the effects which may be expected from them ; and if perchance they prepare better salt than usual, they immediately boast themselves possessed of an extraordinary secret, attributing the alteration to the mixtures made use of, although it might often, with more reason, be ascribed to the slowness or intenseness of the fires, or to other circumstances in the process, to which they do not give a sufficient attention.

THE additions most commonly used to answer the above-mentioned purposes, are the following, viz. wheat flower, rosin, butter, tallow, new ale, stale ale, bottoms or lees of ale and beer, wine lees, and allom.

WHEAT flower hath been used at some salt works to make the salt of a small
I grain ;

grain¹; which effect it may have, either by being interposed between the minute saline crystals, and so preventing their cohesion; or else by rendering the brine more glutinous, and so preventing the saline particles from moving towards each other, and uniting together so easily in that tenacious liquor as in a more fluid brine.

ROSIN hath long been held in great esteem at the Droitwich salt-works, for its property of making their salt of a small grain. And they are of opinion, that by means of this addition they obtain a whiter and finer salt, that measures farther, and is fitter for table use, than any that they could prepare without it. And in preparing basket salt, they add a larger quantity of rosin than usual². The particles of rosin may probably interpose between the little crystals of salt, and prevent their cohesion. But all

¹ “ If they would have it finer than it usually comes
“ of itself, they either draw it with a quick fire, which
“ will break the corns small, or sprinkle the surface of
“ the brine with fine wheat flower, which will make
“ the salt almost as fine as the sand which comes from
“ it.” Plot *Nat. Hist. of Staffordshire*, cap. ii. § 105.

² See Dr. Rastel’s account of the Droitwich salt works. *Ph. Tr. abr.* vol. ii. p. 358, 359.

They still continue to use rosin at those works.

additions applied for that purpose seem unnecessary ; since the same end may be better answered by drawing the salt before it hath lain long enough in the pan to form into large grains ; especially if the brine be stirred about, while the salt is forming ; and the before-mentioned additions, as they render the salt impure, ought therefore to be rejected.

BUTTER, tallow, and other unctuous bodies are very commonly applied as additions ; for the use of which many salt-boilers have little to plead besides immemorial custom. The reason which some of them give for using these unctuous substances, is, that they make the brine crystallize more readily ; or, to use their terms, make it work or salt more kindly. And for this purpose, at some very large works, they think no fat so proper as that of dogs, if I was not much deceived by a salt-officer, who is esteemed a man of integrity. Whether these substances have really the effects ascribed to them, can only be determined by proper experiments. 'Tis however certain, that they have contrary effects upon some kinds of brine, both in England and Germany, and prevent it
from

from forming so readily into crystals³. And they were formerly used by several boilers of sea salt, who now find that they can make as good salt without them⁴. 'Tis therefore most probable that these gross unctuous bodies have much the same effects with rosin, by uniting to the saline particles, and with them forming a kind of soapy mixture, and so preventing, in some measure, their cohesion. When the brine is mixed with alkaline or calcarious salts, these unctuous substances may unite more readily to those salts than to the common salt, and with them may form a kind of soap, and so may prevent them from being reduced into a solid form along with the common salt; and thus may preserve it free from any mixture of salts of a different nature. But the Cheshire salt-boilers, who make great use of butter, do not attend to these its effects, nor do they endeavour to preserve

³ “ In coctione [salis] nihil accedere debeat quod pinguedinem habet, alias ad solidam formam non potest facile reduci:” is a general rule of Hoffman’s, *Obs. Phys. Chem.* Lib. ii. Obs. xvi.

⁴ These additions are now every where laid aside at the marine salterns, except at those at Lemington and other parts of the west of England, where they are still in great repute.

their common salt pure from alkaline or calcareous salts, but harden all their leach brine into salt, as was before related. In which method these unctuous substances may, however, be of some use, by enveloping the alkaline and calcareous salts, and preventing them from dissolving by the moisture of the air ; although the common salt would be much better, if entirely freed from this saponaceous mixture.

SEVERAL kinds of fermented liquors are also used as additions or seasonings ; the chief of which are, wine lees, new ale, stale ale, barrel bottoms, or lees of ale and beer. These additions are now generally rejected by the marine salt-boilers, except in the west of England. The briners, who use them, affirm that they raise a large grain, and make their salt more hard and firm ; and some also say that they make it crystallize or grain more readily. The Cheshire briners use several of these liquors promiscuously, as new ale and bottoms of ale^s, although they have very different qualities, and will probably have different effects upon the brine. Hoffman prefers the strongest

^s See Mr. Lowndes's process.

and stalest ale⁶; and Plot assures us, that it makes the salt of a larger or smaller grain according to the degree of its staleness⁷. And indeed, the only good effects that fermented liquors can have as an addition, are probably owing to their acid spirit, which may correct the alkaline salts of the brine, and so render the common salt more dry and hard, and less apt to dissolve in a moist air. And to the conflict between this acid, and the alkaline salts of the brine, is probably owing the ebullition observed in the pan, when those liquors are added. As to the effect which those liquors can have of

6 “ Coagulationem quoque promovet si non cerevisia sed zythus, aut Lobeiunsis cerevisia, quæ subacida est, aut quod melius adhuc est vinum, sub coctione admiscetur. Quinimo periculum feci, & instillavi rectificati vini spiritus unciam loco cerevisiæ, quo insignem & notabilem immutationem ac coagulationem animadverti, sale candidissimo & admodum granoso evadente. Spiritus enim vini egregie facit ad omnium salium crystallisationem, eo quod unguinosam & unionem salinarum spicularum impredientem substantiam absorbet, & salvas e liquore in fundum dejicit particulas.” Hoffman *De Salinis Hallens.* chap. vii.

The illustrious Mr. Boyle, from a saturated brine, precipitated a considerable portion of finely figured salt, by mixing it with dephlegmated spirit of wine. See Dr. Shaw's *Abb.* vol. i. p. 524.

⁷ *Nat. Hist. of Staffordshire*, chap. ii. § 105.

promoting the granulation, it can only be very inconsiderable ; and the best method of making salt of a large grain, is by means of a gentle heat, as will be more fully shewn hereafter. If therefore it should be thought necessary to use any of these additions, in order to correct the alkaline quality of the brine, stale ale, or Rhenish wine, ought to be chosen, for new ale contains but little acid ; and the lees of malt drink will probably give the salt a disagreeable taste, and other bad qualities ; especially when these dregs are evaporated to a dryness, and hardened up with the salt, as is the practice in the common process of making the Cheshire brine-salt. And to these impurities, together with the saponaceous mixture of butter and alkaline salts, is probably owing the great abundance of thick froth or scum, which arises upon the solutions of several kinds of Cheshire brine and refined rock salts ; and which I did not observe upon the solutions of some kinds of boiled sea salt, in the preparation of which none of these additions were used.

ALLUM is an addition which was long ago known in Cheshire, and there used, together with butter, to make the salt precipitate

pitate from some sorts of brine, as we are assured by Dr. Leigh⁸, who first taught the Cheshire salt-boilers the art of refining their rock salt. 'Tis indeed probable, that they formerly tried many methods in order to correct the bad qualities of their salt, and to render it strong, and of a large grain, and sufficiently firm to endure the air. But as the bad properties of their salt proceeded from hard boiling, they found every method ineffectual, until they had recourse to a more mild and gentle heat. And as allum hath long been difused amongst them, it is not likely that they found any extraordinary benefit from it ; otherwise they would scarce have neglected it, and continued the use of butter. However, a Cheshire gentleman hath lately endeavoured to revive its use, asserting, that “ brine-salt hath evermore
 “ two main defects, flakeyness and soft-
 “ ness ; and that to remedy these imper-
 “ fections he tried allum, which fully an-
 “ swered every thing he proposed ; for it

⁸ “ It is observable the salt of some of these springs
 “ will not easily precipitate, but a little allum and fresh
 “ butter will effect it ; and then it makes a larger grain
 “ and stronger salt than any of the rest.” Dr. Leigh’s
Nat. Hist. of Lancashire, Cheshire, &c. (published at
 Oxford in the Year 1700) p. 44.

“ restored the salt to its natural cubical
 “ shoot, and gave it a proper hardness, nor
 “ had it any bad effect whatever⁹.” But
 whoever considers the nature of allum will
 scarce expect such extraordinary effects from
 it. Neither does it here seem wanted ; for
 the grains of common salt will always be
 sufficiently firm and hard, and of their na-
 tural figure, and of a large size, and no ways
 disposed to run by the moisture of the air,
 if formed by a gentle heat, and perfectly
 free from heterogeneous mixtures, as will
 be more fully explained hereafter. So that
 the goodness of the salt made by that gen-
 tleman, does not seem to be owing to the
 allum, with which it is mixed ; but may be
 attributed, chiefly to the gentle heat used
 in its preparation.

THE Dutch, who have long shewn the
 greatest skill and dexterity in the art of
 boiling salt, make use of another addition,
 which they esteem the greatest secret of their
 art. This is whey, kept several years, ’till
 it is extremely acid ; now first revealed to
 the British salt boilers ; but long held in
 great esteem by the Dutch, for the good

⁹ See Mr. Lowndes’s treatise intituled, *Brine salt improved*, p. 13.

effects it hath upon their salt; which it renders stronger and more durable, and fitter for preserving herrings, and other provisions¹⁰. 'Tis certain, that this acid liquor may temper the mineral alkaline salts mixed with their brine; and may also reduce into a mild neutral salt the alkaline principle of common salt, deprived of its acid spirit by the violent coction used in the first part of the Dutch process, as will be related hereafter. The unctuous particles of this whey may also entangle the calcarious salts of the brine, and contribute to retain them the better in the bittern, and so prevent any of them from forming into crystals along with the common salt. And this whey, being itself a mild acid condiment, can be no ways prejudicial to the common salt, if mixed with the brine in such quantities, as to be predominant over the alkaline salts contained therein.

¹⁰ The manner in which the Dutch use this addition, see related in chap. vii. of this part.

C H A P. IV.

Of white salt prepared from sea water, and other salt waters, first beightened into a strong brine by the sun.

IN several inland parts of Germany, where they have only weak springs of salt water, and also at many places on the sea coasts of England where fuel is scarce, various artifices have been invented for converting those salt waters into a strong brine, which they afterwards boil with culinary fires into white salt.

SOME have exposed those salt waters in open vessels to be congealed in part into ice; and as the water freezes, the salt is in a great measure expelled out of it into the uncongealed liquor; which thus, during hard frosts, is converted into a strong brine.

BUT the same effect is with greater convenience and certainty performed by the

“ Nonnulli falsilaginem frigori exponunt, atque
 “ gelari sinunt, & aptissima est huic scopo illa, quæ duas
 “ aut unam cum dimidia salis uncias comprehendit (scil.
 “ in falsilaginis lib. i.) quæ enim tres, quatuor, aut quin-
 “ que uncias custodit, nunquam frigore densatur: di-
 “ midia vero, aut una uncia facta, tota in glaciem abit.”
 Hoffman *De Salin.* Hall. chap. vii.

heat

heat of the sun, and the operation of the air. For this purpose, in several parts of Germany they erect sumptuous edifices of wood. One of which works at Soda, near Frankfort on the Main, with the method of preparing brine therein, is described by an ingenious traveller, in the following words²:

“ It belongs to Mr. Malapert, and has
 “ been wrought above sixty years.---There
 “ rises at the foot of some little hills which
 “ produce very good wine, a spring of wa-
 “ ter that is so very little brackish to the
 “ taste, that one will hardly think it possi-
 “ ble to fetch much salt out of it, yet it has
 “ such a taste of salt, that there was room
 “ for industry to prepare this water so, that
 “ without such an expence of fire as would
 “ eat out the profit, it might turn to a good
 “ account.---The meadow that lies in the
 “ level with this spring is impregnate with
 “ salt, iron, nitre, and sulphur, but salt is
 “ that which prevails. First then, a pump

² See *Supplement to Bishop Burnet's Letters*. Letter iii.

These the Germans call Leck-oder Gradier-wercke, and have many of them; but they are not all constructed alike; for where the water is saltier, they have fewer cisterns; in some works only one, as at Bevieux or Roche, as hath before been related.

is

“ is put upon this spring, which is managed
“ by a water-mill, and throws up the wa-
“ ter about fifteen feet high ; and then it
“ goes by a pipe into vast machines, that
“ are made to receive it.

“ THERE is a great piece of ground in-
“ closed, in which there are 24 vast chests
“ or cisterns for the water, in two stories,
“ twelve in a story, the one just over the
“ other ; they are about seventy foot long,
“ twelve broad, and two deep ; over every
“ one of these there is a roof of boards sup-
“ ported by wooden pillars twelve foot high,
“ which covers them from rain-water, but
“ yet the water within them is in a full
“ exposition to the sun ; those roofs are
“ hung with straw, upon which some that
“ manage the work are often throwing up
“ the water, so that a great deal of the
“ phlegm is imbibed by the straw, and the
“ more fixed parts fall down. According
“ to the heat of the season, this evapora-
“ tion of the watery parts goes quicker or
“ slower. There is a gage, by which they
“ weigh the water, and so they know how
“ the evaporation advances ; it is of silver,
“ and is so made, that according to the
“ weight of the water it sinks into it to
“ such

“ such a depth, and so by the degrees
 “ marked upon it they know how heavy
 “ the water is. According then to the heat
 “ of the season, and the progress of the e-
 “ vaporation, they let the water out of one
 “ cistern into another, by a pipe ; and
 “ when it hath past through the twelve
 “ that are in the upper story, then it is
 “ conveyed down by pipes into the twelve
 “ that are below ; and in them all they con-
 “ tinue still to throw up the water upon
 “ the withs of straw that are over head.

“ In a word, this evaporation discharges
 “ the water of so much of its phlegm,
 “ that the same quantity of water that
 “ weighed one ounce, when it was drawn
 “ from the spring, weighs six ounces in
 “ the last chest³. And all this rolling about
 “ of the water from chest to chest lasts
 “ sometimes not above twenty days ; but, if
 “ the season is only moderately hot, it will
 “ be longer a-doing : sometimes it will not
 “ be done in a month’s time⁴. After that

³ This is certainly an error ; he probably means that only one sixth part of the water remains, the rest being evaporated from the salt.

⁴ Hoffman, speaking of this method, says, “ Totum negotium minus exoptato succedit, nisi ficcitas per

“ the

“ the water is brought to a very confide-
 “ rable degree of faltnefs, it is conveyed
 “ into two great caldrons that are thirteen
 “ foot long, ten broad, and three and an
 “ half deep, under which there are vaft
 “ furnaces, where, in a moft violent fire of
 “ eleven or twelve hours, the water receives
 “ its laft evaporation ; and when that is
 “ done, the falt, which is become thick,
 “ but is ftill moiſt, is taken up in baskets
 “ of willows, and placed about the wall of
 “ the furnace, ſo that the humidity that
 “ remains in it drops out, and it is brought
 “ to its laft degree of perfection.---There
 “ are vaft quantities made of it in hot and
 “ dry ſummers, for the cheſts are kept al-
 “ ways full ; and thus all Franconia is fur-
 “ niſhed with falt of its own production, at
 “ very moderate rates.”

BUT the Engliſh elaborate ſea water into
 brine by a much eaſier and leſs expenſive
 method than that before deſcribed. This
 is called raiſing or heightening ſea water by
 the ſun ; and there are many large works at
 Lemington in Hampſhire, and in the iſles

“ annum regnet, & commodiſſime tantum adornatur
 “ vento boreali & orientali ſpirante, vernali atque æſti-
 “ vo, non autem hiemali tempore.

of

of Wight and Portsea, also about Pool in Dorsetshire, and nigh Topsham in Devonshire, where this method hath long been practised, to the great advantage of the proprietors of those works ; who though they boil their salt with Newcastle coal, yet can afford to sell it cheaper at London than that which is boiled from sea water in the neighbourhood of Newcastle ; where the coal does not cost above a quarter part of the price paid for it by the owners of those salt works in the west of England.

THE works in which the sea water, is heightened into brine, are called sun-works, or the out-works ; and are constructed nearly after the following manner ⁵.

A PROPER situation, on a flat downs, or ouzy beach is chosen, from which, if there,

⁵ The account here given is the best that I have been able to obtain, having been composed from the relations of several salt-officers, compared with a few hints, which Mr. Brown, Harris, Chambers and others have given us relating to these works. I am very far from offering this as a perfect and exact description ; but as one from which an idea may be formed of the general contrivance of these works. It is to be wished that some person of publick spirit would favour us with a more perfect account of them ; which was much desired by the Royal Society sixty or seventy years ago.

be occasion, the sea is barred out by a mole. Within this mole, there is a large reservoir or feeding pond, which has a communication with the sea by a sluice ; and adjoining to the reservoir, a long trench ; and parallel to the trench several square ponds, nine or sometimes twelve in number, all placed in a row, the whole length of the trench ; and parallel to this row, two other rows of square ponds, equal to those in the first row in number and dimensions. These ponds they call brine pits. Beyond the third row, is a row of larger ponds three in number, with each of which, three or four of the brine pits in the third row communicate by narrow openings. These they call fun pans ; and these three fun pans often communicate with another larger pond, which they call the common fun pan, from which the brine flows into large covered cisterns (made very tight of brick and clay) adjoining to the boiling house. All these ponds, with the partitions between them, usually cover about two acres of ground.

THE bottoms of the ponds, are in several places, as at Lemington, made of an ouzey mud ; to make which hold water, they tread it down very hard with boots
that

that have flat soles, and afterwards lay it very smooth, and in the brine pits and sun pans, cover it with sea sand ; which prevents the ouzey bottoms from cracking when dry, and makes them better retain the sun's heat, and more readily exhale the watery vapours. The bottoms of all the pits form an inclined plane, which is highest at the reservoir, and lowest at the common sun pan ; but where the ground will not admit of such a declension, the water is raised up by a scoop and trough, which turn upon an axis ; and the scoop receiving the brine from the lower pond, when it is raised up, it falls into the trough, through which it runs into the higher pond adjoining. The partitions between the ponds are all of mud and earth, a foot and an half or two feet broad, and have little openings by which the pits communicate one with another ; and these openings are closed with mud, when occasion requires.

THE sea water being received into the reservoir at full sea, is from thence let out, as occasion requires, into the trench ; and from the trench, into the first row of brine pits ; and when they are filled to a certain height, the openings between them and the trench are dammed up with mud. When the water hath stood a due time in this first row of
I pits,

pits, it is let out into the second row, which before were empty, and the bottoms of them exposed to the heat of the sun. After a certain time, which is longer or shorter in proportion as the evaporation advances, the brine is let out of the second into the third row of pits; and about the same time the first row of pits are again filled; the several rows being thus emptied and filled alternately. When the brine is sufficiently evaporated in the third row of brine pits, it is suffered to flow into the sun pans; and afterwards into the common sun pan; where they examine its weight by means of glass hydrometers; and when they find it of a due strength, they draw it from thence into the cisterns; where it is stored up till they have an opportunity of boiling it.

THE sea water, which was received into a row of the brine pits, and carried forward together through the whole work, is called a course of brine. And sometimes when the weather is excessive hot, it is brought to its full strength, and performs its whole course from the trench to the cistern in twenty four hours. But when the weather is less favourable, it requires a much longer time for its passage. And sometimes, when they observe
showers

showers approaching, they draw it off into the cistern before it is brought to its full strength. In this course the salt water stands deepest in its first row of brine pits, and gradually shallower in the several pits, till it arrive at the sun pans, where it stands shallowest; in the common sun pan it is six or seven inches deep, being there deeper than in the smaller sun pans.

AND after this manner, if the season prove favourable, they make as much brine as keeps them boiling till nigh Christmas; after which they repair their pans and furnaces, and prepare their Epsom salt from the bittern, and begin again to make brine about April.

THE pans in which they boil the salt at Lemington are of lead, of a square form, and smaller than those before described for boiling sea water into salt. They usually have four of these pans in a saltern, all placed in a row, with a distinct furnace to each of them. The chimnies are carried up by the side of the wall, which divides the boiling house from the forehouse; and the smoke is conveyed from each furnace into these chimnies by two flues, one on either side of the mouth of the furnace. To each of these flues is fitted a register, or plate of iron,
K placed

placed horizontally, which, by means of a handle, may be drawn out, or thrust in over the flue, so as to close it and prevent the smoke from ascending through it. And by means of these registers, and vent-holes, and doors to the mouths of the furnaces and ash pits, they can regulate the fires in the exactest manner, and can damp them while the salt is graining, or smother them quite out, if they see occasion.

In the boiling house they have a chimney to convey off the vapours from each pan ; it is a square funnel of boards, which is not carried down so low as the pan ; but room is left below it for the salt-boilers to draw the salt, or to do any other business about the salt pan. There is only one long walk in the boiling house, on the side of the pans opposite to the mouths of the furnaces ; and between this walk and the wall, are placed large wooden troughs, with many little holes in their bottoms ; into which troughs the salt, when drawn out of the pans, is put to be drained from the bittern. Below these troughs others are placed to receive the bittern ; and in them several sticks are fixed erect, to which the cat salt adheres in large crystals

crystals⁶. This (as I am informed) is the general construction of the Lemington salt-erns, which seems very artful and commodious.

THE process for boiling salt is much the same here as at the brine works. Only it may be proper to mention a few particulars in which there is a difference. And first, at the Lemington works they use no clarifying mixtures, which are there unnecessary, as the brine commonly ferments in the cisterns, and by that means the texture of its viscuous matter is broken, the more gross parts whereof, together with the light mud, subside to the bottom of the cistern. They boil the brine violently till a thin skin of salt appears on its surface⁷; and then damp the fire, and carefully skim off this skin, and also take out the calcarious earth and cast it away. This earth they do not collect into scratch pans, as at most other works, but suffer it to settle to the bottom of the pan, and rake

⁶ The cat-salt is common salt, which concretes round these sticks in large clear lumps; it holds some of the bitter purging salt; it is very sharp and pungent; and, when powdered, white; and is used by some for the table; but the greatest consumption of it is among the cake soap-boilers.

⁷ They say then that the brine begins to yew.

it to the side, and thence draw it out. The brine being cleared from the scum, they then add to it butter, and other seasonings; and afterwards proceed to grain the salt with moderate fires, although they grain it more hastily here than at most works, commonly reducing three pans full of brine into salt in twenty four hours. When the salt hath remained in the troughs six or seven hours, it is taken out; and, without any other preparation, laid up in the store houses for sale^s.

^s A salt-boiler with an assistant attends four pans, and also prepares the brine in the out works. The salt-boiler for wages receives 1 s. 6 d. per quarter, or six shillings per tun for all the salt made; out of which he pays the assistant. Of this they reckon 10 d. per quarter for boiling the salt, and 8 d. for preparing the brine. They can afford to sell the salt at these works, free of excise, from 1 l. to 1 l. 6 s. per tun, according as the season has been more or less favourable for making it, or according as there is a demand for it. Whereas at Newcastle the profit is very small, when they sell their salt for 30 s. per tun; although it is sometimes sold there for 27 s.

C H A P. V.

Of white salt made from a strong brine drawn from earths, sands, and stones impregnated with salt.

THE strong brine or lee which is drawn from saline earths, sands, and stones¹, and afterwards boiled into salt, is prepared after different ways.

IN several parts of Germany, as at Inn'thall² nigh Inspruck in the county of Tyrol, and at Halleim in the archbishoprick of Saltsburgh, also at several places in the Upper Austria, there are deep mines, in which they dig salt mixed with much mud and earth. This impure salt, or saline earth, they do not draw out of the mines, but break into pieces, and cast it into pits at the bottom of the mines; these pits they fill up with water, and when the water has stood

¹ Brine prepared in this manner is called Dilutum by Agricola.

² The mines are said to be four miles distant from the city, and the brine is conveyed all that way through troughs, to the salterns. At these works, when Mr. Addison was there, they made at the rate of eight hundred loaves of salt a week; each loaf being four hundred weight.

in them some weeks, it becomes a fully saturated brine, each pound of it having absorbed six ounces of salt. This strong brine is then drawn out of the mines, and conveyed through wooden channels to the salterns, and boiled in iron pans into white salt, for which they find a sale in Bavaria, Stiria, Carinthia, and in some of the Swiss cantons, and amongst the Grifsons³.

In other places they do not dig out the saline earths and stones, but introduce freshwater into the places where they are lodged, and the water being impregnated with the salt is thence drawn out, and evaporated in proper vessels⁴.

³ Vide Hoffman *De salinis Hallens.* Cap. ii. et iv. Et *Obs. phys. chem.* Lib. ii. Obs. xvi.

“ On voit aussi dans l’Autriche supérieure, au lieu
“ appelé Mund, (où il y a des montagnes, qui ont des
“ veines remplies de sel) de somptueux edifices de bois,
“ pour conduire les eaux insipides dans les endroits où
“ est ce sel, afin que la dissolvant, elles en prennent le
“ gout.” Comte Marilli, *Hist. de la Mer*, p. 22.

⁴ A French traveller takes notice that the waters at Roche are insipid before they pass over veins of salt, whereof they instantly take the acrimonious favour. The galliery cut through a rocky mountain for the passage of this salt water to the saltern, he says, is five hundred fathoms in length.

Saxa ipsa (in putei cuniculis, magno labore excisis) salinis particulis referta; quæ indicio sunt manifesto esse sal hoc Bactiacum fossile, ab aqua fontana solutum, rursumve arte concretum. Scheuchzeri *Iter Alpin. Septimum*, on the same salt works.

IN

IN other places a strong brine is extracted from sea sand; which brine is afterwards boiled into white salt. There are very considerable works of this kind at Mount St. Michael, and other places upon the coasts of Normandy; where this salt is made so cheap, that it is often exported to London; although loaded at that market with a heavier duty than British salt. There were formerly several works of the same kind at Wire-water, and Medop in Lancashire, and at Milthorp in Westmoreland; at which places, pit-coals being scarce, they boiled the salt with turf fires; but since brine salt, and refined rock salt have been made in such plenty in Lancashire and Cheshire, all those sand works have gone to decay; and that method is, in those parts, intirely laid aside; except at one or two very inconsiderable works nigh Ulverstone in Lancashire.

THE sand from which they prepare the brine at the works nigh Ulverstone, is collected on flat sandy shores, on those parts of them which are only covered with sea water in the high tides which flow two or three days before, and three or four days after the full and new moon; for those parts of the sands which are overflown by the

neap tides, are seldom sufficiently dried, and are at too great a distance from the salterns.

THIS sand they collect in flats and washes, or in parts of the sands which are perfectly plain, and in little hollows where the sea water is left, and either sinks into the sand, or is dried up by the heat of the sun, leaving the salt behind. The sand is only collected in dry weather, when the sea water hath been exhaled from it by the sun, and the rains have not washed the salt out of it. At such times, and in such places they rake up the sand into heaps, to the depth of two or three inches, and convey it to their works in carts; laying it up in a large heap, where it is exposed to the weather, and subject to be much injured by rains. They therefore work it up with all diligence, and rarely boil any salt in the winter season.

IN order to extract the salt from the sand; adjoining to the saltern, they dig a pit eighteen feet long, three feet broad, and one foot deep. The bottom of this pit they cover with rushes, or straw, and then fill it up with the salt sand from their heap; upon the sand they pour sea water, which they take into a pond or sump at spring tides; the

the water imbibing the salt from the sand, filtrates through the rushes or straw, and runs through a pipe from the bottom of the pit, into a cistern placed in the boiling house. They continue pouring sea water upon the sand, so long as the brine in the cistern will bear a hen's egg to a certain height. And thus having extracted most of the salt from the sand, they remove it, and fill up the pit with fresh sand from their heap.

THE brine being thus prepared, they boil it with turf fires in small leaden pans; in which they only make about two gallons of salt at each process, which is usually performed in four hours. They use no clarifying mixtures, but take off a scum, which arises in great plenty when the brine begins to boil^s. They drain their salt in wicker baskets, which they hang up in the hottest part of the saltern. After each process, they throw out the bitter that remains in the pan; and about once a day, while the pan is hot, remove it from the fire, and beat it with a wooden mallet, and thus free

^s We are told that in Normandy, while the salt is graining, they stir it continually with wooden ladles.

it from the calcarious crust which adheres to its bottom and sides⁶.

C H A P- VI.

Of refined rock salt.

TH E practice of refining rock salt, and converting it into white salt, hath long prevailed in several countries, particularly in Great Britain, Hungary, and Poland.

THE Cheshire fossil salt is esteemed unfit for domestic uses, untill it hath undergone this preparation'. Vast quantities of it are now refined in that county, being first

⁶ This shews that Dr. Lister was mistaken in supposing, that the scratch was formed by boiling the brine in iron pans; because he observed none in the Droitwich brine, which was boiled in lead pans.

¹ We are informed in the *Philosophical Transactions*, that the mines out of which this salt is dug, were first discovered in the year 1670, in boring for coals in the liberties of William Marbury of Marbury, Esq; where it lay thirty-three or thirty-four yards from the surface, and that from it there issued a vigorous sharp brine, stronger than any then used in Cheshire.

At present many mines of this salt are wrought nigh Northwich, by several proprietors, most of whom are united in one company for the more convenient carrying on of their works.

dissolved in weak brine². Large quantities of it are also carried in boats down the rivers Weever and Mersey; and either refined at Dungeon and Liverpool, where they take up salt water out of the river Mersey at full sea, to dissolve it in; or else shipped at Liverpool, and transported by sea along the British coasts, and into Ireland, to places where it is boiled into white salt with sea water³.

THE works where they boil rock salt are called refineries; at those works at Dungeon and Liverpool, the rock salt is broken small, and thrown into leaden cisterns, and there dissolved cold in sea water. In these

² The refined rock and brine salts are exported from Liverpool in very large quantities to many parts of Great Britain and Ireland; and also to the American colonies, more especially since the commencement of the present war, whereby the inhabitants of those colonies have been prevented from supplying themselves with sufficient quantities of bay salt.

White salt is usually sold at Liverpool for about one Pound per tun, exclusive of the duty.

³ It was provided by act of parliament, that no rock salt should be refined at any works in Great Britain, distant above ten miles from the mines where it is got, except at such works where it was refined before the said act took place. By another act, a large duty was laid upon rock salt exported to Ireland; but the time for which that duty was imposed being expired, and the act not renewed, many refineries have lately been erected in that kingdom.

cisterns

cisterns the strong solution remains twenty-four hours to settle, and is then craned off from the sediment into the salt pan, and there boiled into salt, as is practised with natural brine, it being clarified in the same manner, and mixed with the same additions. During the process, large quantities of scotch fall from it, as from natural brine.

The leach brine is not thrown away as at the marine salt works, but is preserved and mixed in the pan with the solution of rock salt, and with it boiled up, as at the Cheshire brine works.

C H A P. VII.

Of the Dutch method of preparing salt upon salt.

IN Holland and Zealand, the Dutch for ages past have practised the art of refining salt with the greatest success; and to their extraordinary skill in this art, are in a great measure owing the advantages which they have over other nations in the herring fishery; since fish preserved with their refined salt, look much cleaner and fairer than those that are cured with bay salt, and keep
much

much better than those preserved with any other kind of white salt. And although inquiries into this art seem of great importance to a trading maritime nation, yet they seem to have been almost wholly neglected by my countrymen; or if any of them have got a knowledge of this art, they have concealed it out of views of self-interest, or other private motives.

BUT as I am persuaded, that a more general knowledge of this art may be of public use, and being under no tie of secrecy; I shall therefore act in this as I have done in all other cases, and faithfully reveal such particulars relating to this art, as I found means of obtaining during my residence in Holland, from several persons of credit, who had the best opportunities of informing themselves about it.

THE Dutch prepare two kinds of refined salt; the one of a small grain for table use, which they call butter salt, and export in large quantities up the Rhine, and into other parts of Germany. The other sort is a very strong pure salt, of the largest grain of any boiled salt now made; and this they call Saint Ubes or Lisbon salt; from its resemblance

semblance to the pure bay salt brought from those places:

THE salt which they refine is altogether marine bay salt; which they have chiefly from France and Spain. As from Rochelle, Souston nigh Bayonne, and Cadiz¹. They find by experience, that any one kind of bay salt does not answer their purpose so well as several kinds mixed. They therefore frequently mix three parts of Spanish salt with one of that of Souston; which last is much esteemed for its great strength, but is very dirty, and of a bad green colour, and does not cost above half the price of the Spanish salt; however, they esteem a certain proportion of it necessary, but are obliged to use it sparingly; for the operators affirm that more than a quarter part of it would render the refined salt, black and unfit for sale.

FOR dissolving the bay salt they use sea water, which they bring to Dort and Rotterdam in large lighters from below the Briel or Helvoet. Out of these lighters it is craned into cellars, where it is impreg-

¹ For some time indeed they used considerable quantities of the English rock salt; but I am informed that the use of it was prohibited by the States; who found that the salt which they prepared with it was not so good as the refined bay salt.

nated with the bay salt to a certain degree of strength, of which they judge by hydrometers made for that purpose.

AFTER the heavy dross of the salt hath settled to the bottom of the cellar, the clear brine is pumped up into the salt pan through a mat, which retains the light scum, straws, or other impurities which still may float therein.

THEIR salt pans are made of iron, commonly of a round form, and of an extraordinary magnitude ; being usually forty feet in diameter, and eighteen inches deep ; and are bound round very strongly with large bars of iron².

THESE pans are placed over a hearth furnace. The fuel which they burn in these furnaces is altogether turf, which they endeavour to procure as dry as possible ; wet turf being found to corrode their pans, and to make them consume more quickly than that which is dry³.

² I have been told, that, when these pans are new, they wash them over with lime and water, which preserves the pan from rust, and never wears off. But it seems more probable, that they only fill up the joints with lime, as we do in England.

³ It hath been reported, that the Dutch use pit-coal at their salt works. It is true indeed, that for all works where pit-coal is necessary, as for light-houses, glass-

The pan being filled with brine, and the fire kindled, the brine is made to boil violently, and if any scum arises they take it off, but do not use any clarifying mixtures⁴.

A LITTLE before the salt begins to form, they slacken the fire, and add to the brine the bigness of a walnut of the freshest butter⁵, and half a pint of their sour whey before described, taking care to stir it well about, that these seasonings may be every where equally mixed with it. They then shut up the doors and windows of the sal-houses, smiths forges, the States wisely encourage the importation of pit-coal, and suffer it to be used duty free. By which means the Dutch manufacturers have those coals cheaper at such works than the English, when only carried from one of our ports to another. But the case is different when pit-coals are used in Holland for common fires, or in works where they are not absolutely wanted; for then they are laden with a heavy duty, in order to prevent the consumption of a foreign commodity. And, as in refining salt, the Dutch chiefly apply slow and regular fires, turf seems as proper for that use as pit-coal. It is therefore most likely, that agreeably to the wise policy of their government, and the informations which I have received, the Dutch, in refining salt, use fires of turf, which is the product of their own country.

⁴ One gentleman informed me, that they clarified with whites of eggs, but two of the Dutch salt boilers asserted the contrary.

⁵ I have reason to suspect that the butter is added only when they make their table salt, which they call butter salt,

tern,

tern, so that no fresh air can blow into the pan ; and the house becomes very hot ; and is thus kept close all the time that the salt is graining⁶.

IF they make table salt, the brine is suffered to simmer gently during the granulation, and the whole process is finished in twenty-four hours.

BUT when they make their strong salt for curing provisions, they only use an extremely mild and gentle heat, so that three days are usually spent in the process, before the brine is sufficiently evaporated.

IN both cases, they suffer the salt to remain in the pan 'till the process is finished, and then rake it to the sides with wooden rakes, the handles of which are twenty feet long. It is then taken out, and, after the brine hath drained from it in wooden drabs, it is fit for use⁷.

⁶ At many of the German salt works, where they boil brine salt, they also exclude the cold air from the pan, while the salt is graining, by boards placed on every side of it, after the manner directed by Agricola.

⁷ The table salt is usually sold at the works for about twenty-four styvers, and the strong salt for about thirty styvers the bushel ; and their bushel is said to contain about fifty pounds of the table salt, and eighty pounds of the strong refined salt. There is probably a greater duty upon the table salt than upon the strong refined salt, which makes the latter cheaper than the former.

THE mother brine, of which there remains a large quantity in the pan after the strong salt is made, as also that which drains from the salt in the drabs, is reserved to be boiled up for table salt, being never used in preparing the strong salt.

BUT the mother brine of table salt, after each process becomes more sharp and bitter ; and is therefore, at certain times, thrown out as useless ; great care being taken to wash it well out of the pan before they propose to make their strong refined salt.

APPEN-

A P P E N D I X

To the foregoing

H I S T O R Y.

C H A P. I.

Of the qualities of the several kinds of bay salt.

HAVING, in a brief manner, related the various methods of preparing salt, as now most commonly practised ; it will in the next place be necessary to subjoin a short account of those qualities, which salt acquires chiefly from the different ways of preparing it ; that so, those methods may be chosen by which a salt is made most proper for the use of the table, or for preserving provisions ; and those methods may either be amended or rejected,

by which a salt is prepared less fit for the abovementioned purposes.

AND first ; the several kinds of bay salt differ from each other, chiefly in the following particulars, viz.

1. *In the size of their crystals.* For bay salt, in proportion as it lies a longer or a shorter time in the pits, or as the solar heat, or force of the air is more or less powerful, will be formed into greater or smaller crystals. Upon these accounts the French cream of salt, and the blown salt of the Isle of May, which are skimmed off the surface of the brine, are of the least grain. The Portugal salt is commonly of a larger shoot than that of France ; and that of Tortuga, much larger than that of Portugal.

2. *In purity.* For there is scarce any bay salt which is not mixed with several heterogeneous substances ; as slime, mud, sand, and clay, which are raked up with it from the bottom of the pits where it is made, or mixed with it whilst it lies on the ground in heaps. There are some kinds of bay salt which are mixed with bitter purging salt, and probably with other salts. From all which mixtures it acquires peculiar qualities.

3. FOR

3. FOR from the mixture of clays and earths it acquires *various colours*. The French bay salt is commonly grey; where the bottoms of the pits are of blue clay, it is more white; where of a red clay, it hath a reddish cast; and that of Souston, nigh Bayonne, is of a greenish colour. The Portugal and Spanish salts are whiter and purer than the French, but yet retain a considerable mixture of mud and dirt. In general, all salt when dry, is more white; when moist, more pellucid.

4. SOME kinds of bay salt are *more apt to contract a moisture from the air* than other kinds. And this either because the salt is of a smaller grain, and comes into contact with the air in a greater number of points; or else, because of some mixture of calcareous, or alkaline salts, which greedily imbibe the aqueous moisture.

5. SOME kinds of bay salt are distinguished by their *smell*; as the Hampshire and Portugal bay salts, which have a fine violet flavour when stored up in large heaps; probably from the oleaginous or sulphureous particles mixed with sea water, or imbibed by it in the ponds, and there altered and subtilized by fermentation.

6. BAY salt, from the variety of substances mixed with it, differs greatly in *taste*, as well as in other qualities. Thus, according to Galen, the salt of the Lake Asphaltites, or Dead Sea, is extremely nauseous and bitter; probably from bitter purging salt, and other mixtures¹. The salt made at the springs of Peccais in Languedoc hath also a bitter taste². Whereas the salt made

¹ As from bituminous substances, which abound in other salt waters, as well as in those of the Dead Sea. The reader may give what credit he thinks fit to the following instance from Pliny. “Fit [scil. sal communis] et e puteis in salinas ingestis. Prima densatio Babylone in bitumen liquidum cogitur, oleo simile, quo & in lucernis utuntur: hoc detracto subest sal.” *Nat. Hist.* lib. xxxi. cap. vii.

² Comte Marfilli says, that this salt is made of salt-water drawn from deep wells, and gives the following account of it.

“Le goût du sel, que l’on fabrique à Peccais, est salé,
 “amer, & si désagréable, qu’il n’est pas possible de
 “s’en servir, la première année. On a peine de s’y ac-
 “coutumer la seconde; mais on dit, qu’à la troisième
 “il se rend supportable; & qu’à la quatrième son amer-
 “tume est fort peu sensible; & va toujours ainsi, en
 “diminuant à proportion du progrès des années. On
 “a coutume dans ces salines d’y disposer la récolte de
 “l’année, en masses, auxquelles on donne le nom de
 “l’an, qu’elles ont été faites. Elles restent de la sorte
 “abandonnées à l’injure du tems, qui purge le sel de
 “cette amertume pendant trois ans tout au moins, avant
 “que l’on commence à le distribuer,

in

in the Cape de Verd islands, Salt Tortuga, and in many other places from the water of springs and lakes hath a very agreeable taste. Although bay salt made from the same kind of water in different pits, or from other different circumstances attending its preparation, may differ greatly in taste as well as in other qualities. Thus the marine bay salt, although commonly palatable, may sometimes acquire a bitter taste, from calcareous salts mixed with it; as may happen after long drougths, when the pits from which it is drawn have not been freed from bittern.

7. BAY salt oft-times *alters in taste, as well as in other qualities, by long keeping.* The salt of Peccais for example, which, when first made, is so nauseous and bitter as to be unfit for domestic uses; by keeping, acquires a taste that is more agreeable. For the bitter purging salts being very soluble in water, easily dissolve by the moisture of the air, and sink through the common salt in a liquid form, leaving it more pure, and free

“ Jusques à la dernière inondation du Rhone, qui fit
“ fondre dans ce lieu-là une si grande quantité de sel, il
“ y en avoit toujours eu de dix années.” *Histoire Physique de la Mer*, Partie ii. pag. 35, 36.

from its bitter taste. These calcarious salts may also be frequently washed by rains from amongst bay salt, as it lies in heaps exposed to the weather. Alkaline salts may, after the same manner, be discharged from amongst common salt; or when long exposed to the air, may imbibe its volatile acid spirit, and with it be converted into a neutral salt. And for these reasons, not only bay salt, but most other kinds of common salt, become better and fitter for domestic uses, by being kept a considerable time exposed to the air in a dry place.

C H A P. II.

Of the different qualities of white salt.

WHITE salt, as well as bay salt, is commonly mixed with various impurities, which it receives from the waters from which it is extracted; and from these impurities, and the different methods used in its preparation, it is found to acquire very different properties.

I. THE *grain of white salt differs greatly*, according to the manner of its preparation, as hath before been related. The loaves of salt, or basket salt, is of the finest grain, being

ing rather powder than crystals of salt. Of the British sea salt, that made at Lemington, and of the British fountain salt, the shivery salt, are of the largest grain. But the crystals of the salt which the Dutch make for curing provisions, are much larger than those of any other kind of boiled salt.

2. WHITE salt also differs greatly in the *hardness and firmness of its grain*; some kinds of it being of a soft, loose, open grain, which readily crumbles between the fingers; whilst other kinds are of a firm, hard, regular grain, which is not so easily broken.

3. IT hath before been observed, that the *heterogeneous substances* most commonly mixed with bay salt, are clay, mud, and dirt; but those from which white salt is seldom perfectly free, are the calcarious earth called scratch, and the salts of bittern; it is also frequently contaminated with the additions before spoken of, and with dirt, ashes, coal, soot, and other impurities: from all which it receives peculiar qualities, as will be more fully explained hereafter.

4. BOILED salts differ greatly as they are *more or less durable in the open air*. For violent boiling of the brine not only makes the salt of a small irregular grain, as was before

fore observed, but also disposes it more strongly to attract the moisture of the air, and to run with it *per deliquium*. And the operators say of such salt, that it is not well cleared from the fresh. Alcaline salts, and the other salts of bittern, as they greedily imbibe the aqueous moisture, dispose the common salt, wherewith they are mixed, to grow soft and relent in the open air, as hath before been observed. It is a general observation, that the larger the grain of salt, (*cæteris paribus*) the more durable it is in the open air. And salt made up into loaves will remain drier than salt of the same kind which hath its grains disunited.

5. THE several kinds of boiled salt also *differ in colour*. That which is of the smallest grain, the purest, and driest, is commonly the whitest. Most of the salt made in Scotland, is of a dirty grey colour, not being cleared from mud by clarifying the brine.

6. WHITE salt hath commonly *no smell*; but sometimes the corrupted blood used in clarifying it, or the unctuous substances added to it give it one which is very disagreeable.

7. THE several kinds of white salt are also found to *differ greatly in taste*; for some kinds have a much more sharp and pungent
taste

taste than others. In general, that which is of a large grain, and made with a gentle heat, hath a sharp, biting taste; whilst that which is made with hasty fires, and of a small grain, tastes commonly more flat, and soft. There are some kinds of white salt in which a bitter taste may plainly be discovered; as in sea salt boiled with hasty fires, and not drawn from the bittern at a proper time. The cat salt, which crystalizes in marine bittern, hath also a bitter taste, but is sharp, and strong. Moreover, salt hath sometimes a very nauseous taste from corrupted blood¹, and other impurities mixed with it by ignorant operators.

8. WHITE salt often *undergoes considerable alterations by keeping*. The alkaline salts intermixed with it being converted into neutrals by the aerial acid; or else melted out of it together with the bitter and calcarious salts by the moisture of the air. The scratch contained in it may also germinate with calcarious salts. It is found by experience, that sea-salt prepared after the process before

¹ Dr. Plot asserts, that the blood used in clarifying salt gives it an ill colour, as well as a bad flavour. *Hist. of Staffordshire*, Chap. ii. § 107. This is confirmed by Dr. Rastel, in his account of the method of preparing salt at Droitwich.

related,

related², grows dryer for two or three days whilst it remains in the crebs; during which time the leach brine drains out of it, and the moisture also exhales from it by its heat. For some time after it gains in weight; but afterwards grows dry, and, if not often stirred, becomes rocky, adhering together in one solid mass.

9. WHITE salt is also found to *differ greatly in strength*. That salt may be esteemed the strongest which hath the most brisk and pungent muriatic taste, and which is found the fittest for curing fish, flesh, and other provisions, and will preserve them longest in hot countries; and will keep them sweet and good when applied in a smaller quantity than is necessary of other kinds of salt. Of the salts abovementioned, bay salt, and the Dutch refined salt, are the strongest; the shivery salt made in Cheshire is next in strength; and after it, some kinds of brine salt; although a salt equally strong may be made of the English rock salt or sea water. The English refined rock, and sea salts are of different degrees of strength, according to the art used in preparing them; so that some kinds of them are good strong salt, whilst

² In Part ii. Chap. ii.

others are wholly unfit for preserving provisions.

C H A P. III.

Of the uses of salt as a seasoning to our food.

SALT hath been used by mankind as a seasoning to their food, in all ages, and by all nations, except some of the most barbarous, who are destitute of the necessaries as well as the conveniencies of life. It provokes the appetite, strengthens the stomach, promotes the digestion and concoction of the aliment, resists putrefaction, prevents unnatural concretions of the humours, and is most friendly and agreeable to the human body, entering its composition as a necessary ingredient. No wonder therefore that the Laplanders¹, amongst whom the use of salt is un-

¹ “ Bread and salt are unknown to most of them (the
 “ Laplanders) they using for bread, dried fish beaten to
 “ powder: and for salt, the inner bark of pine trees
 “ prepared after this manner. viz. They unbark the tal-
 “ left of those trees, especially that part which is next to
 “ the ground, and take of it the inner bark, whose several
 “ coats they part asunder, and expose them well
 “ cleaned to the sun to dry: then they tear them into
 “ small parts, and put them into pretty big boxes, made
 “ of the outer bark of trees. These boxes they dig un-
 “ der ground, and cover them with sand, and so let them
 known,

known, seem to discover the want of it, by the exility of their bodies, and the weakness of their constitutions ; being much less robust and strong than other northern nations, who enjoy this excellent gift of God. Moreover its uses extend to many other animals besides the human race ; black cattle and sheep take a pleasure in licking it, and by it are preserved from many diseases² ; they also thrive to admiration, and quickly grow fat in marshy grounds that are frequently overflowed by the sea. And if we descend to the vegetable tribe, we shall find that salt contributes greatly to fructify the earth ; and when properly used as a manure, affords

“ be macerated for a whole by their own heat. Then
 “ they make upon those boxes a great fire of blocks
 “ of trees, by which those inner rinds acquire under
 “ ground, a red colour and a grateful sweetish taste,
 “ serving them for a condiment, and supplying the
 “ place of salt.” *Ph. Transf.* N^o. 102. p. 35. Ex-
 tracted from *Johannis Shefferi Lapponia*.

² “ In Hungaria, Polonia, Russia, Transylvania, Bo-
 “ russia, necnon Græcia salis fossilis frustra animantibus
 “ objiciantur, ut ejus usus internam corruptionem &
 “ morbos arceat.” *Fred. Hoffman De fontib. salis Hal-
 lensibus, &c.* cap. vii.

“ Quin & pecudes armentaque & jumenta sale max-
 “ ime sollicitantur ad pastum, multò largiore lacte, mul-
 “ tóque gratiores etiam in caseo dote. Ergo hercule vita
 “ humanior sine sale nequit degere,” &c. *Plin. Nat.*
Hist. Lib. xxxi. cap. vii.

ample nourishment to corn and other vegetables ; and renders kingdoms rich and fertile where it happens to abound in the soil⁴.

As salt possesses these and many other excellent qualities, it therefore deservedly obtains a constant place at our tables, as a seasoning to our food.

IN different countries, different kinds of salt are applied to this use, as best suits with the conveniency or inclinations of the inhabitants. Many nations are wholly supplied with fossil salt ; some for table use prefer bay salt, which indeed hath the advantage in the sharpness of its taste ; but the mud

⁴ The Rev. Dr. Shaw observes, that the soil in Barbary is generally impregnated with common salt and nitre, and that the waters of most of the rivers and lakes have there a salt taste. And to this grand and inexhaustible fund of salts, he very judiciously attributes the great fertility for which that country hath always been remarkable ; and still continues to be so without any other manuring, but the burning, in some few places, of the stubble.

On the contrary, where this salt too much abounds, it kills all vegetables, and renders the earth unfruitful, as may be observed in grounds that have been too long overflowed with salt water. Many arguments might be used to shew that the barrenness of several African and Arabian deserts, proceeds in a great measure, from too great abundance of salt.

and

and dirt commonly mixed with it, and more especially with the French bay salt, render it less pleasing to the sight. Several, therefore, who are curious in the choice of table salt, use the French cream of salt, or the blown salt of the isle of May.

OTHERS, who would have a cleaner and whiter salt than the common bay salt, choose the purest and largest lumps of it, and reduce them to powder. Others wash them, and dry them before the fire, or in the sun, before they powder them; and are thus furnished with an excellent salt for the table, which they call powder salt.

BUT in most countries, where boiled salt can easily be had, the preference is given to it for table use. And for this purpose, that is most esteemed which is the cleanest, and driest, and whitest, and of the finest grain. Such is the English basket-salt; although much of it is very weak, and of a flat taste, being boiled with hasty fires. Other kinds of white salt, although commonly mixed with scrach, and alkaline and calcarious salts, yet need not be rejected for table use; since those impurities are taken in such small quantities that they can have very little effect upon the human body; and their effects will

as a condiment or pickle. 161

in most constitutions, be salutary rather than noxious.

C H A P. IV.

Of the use of salt as a condiment or pickle,

BESIDES the use of salt as a seasoning to our meat, it is also deservedly esteemed the most proper condiment or pickle for most kinds of food which it is found necessary to preserve.

IN the choice of salt for a seasoning, regard may be had to the palate, or to convenience ; but much greater care is necessary in the choice of salt designed for curing provisions. For several kinds of salt are wholly improper for that purpose ; and several kinds of food require a stronger or weaker salt, to be used in larger or smaller quantities, either, first, according to the different manner of preserving them ; or secondly, according to the different nature and qualities of the substances preserved ; or thirdly, according to the climate, place, or season of the year in which they are cured ; or lastly, according to the uses to which it is proposed to apply them.

FOR first, those kinds of animal food which are salted, and afterwards dried either in the sun, or by kitchen fires, are often as

M

well

well preserved with a weaker, as with a stronger kind of salt; and sometimes even better, very strong salt being apt to make them too hard, and too salt, and not so agreeable and wholesome. Thus some of the best kinds of hams are cured with common white salt, to which a little saltpetre is added¹; and thus preserved they are found more soft and juicy, and not of so fiery a taste as those preserved with strong bay salt. Dried meats may also be more easily cured with a weak salt, than pickled meats. For the juices of animal substances being inspissated by the heat used in drying, cannot run into those intestine motions which are the cause of putrefaction. The acid of wood or turf smoke, to which those substances are exposed, may also contribute to preserve them. In the West Indies they can scarce cure beef with pickle; but easily preserve it by cutting it into thin slices and dipping them into sea water, and then drying them quickly in the sun; to which they give the name of Jerked beef. Several kinds of white fish are also easily cured by drying them in

¹ In Virginia they cure their hams with bay salt; and it is there a common practice to rub them with the ashes of hickory wood, instead of salt-petre, in order to give them a red colour.

the sun, either without salt, or with only using a very little.

2. SOME kinds of animal food are cured with much greater ease than other kinds; and those require the strongest salt and the greatest quantity of it which are cured with the greatest difficulty. In Virginia, and other parts of North America, they can pickle beef with Liverpoole salt, so as that it will bear exportation to Barbadoes, and others of the Caribbee islands; but cannot rightly cure pork, for exportation to the same islands, without bay salt. Herrings and other kinds of fish, which abound in a thin subtile oil, are more disposed to putrefaction, and require a stronger salt to cure them, than cod and other white fish, which are less juicy and unctuous. The livers of most animals, especially of fish, are so apt to corrupt that they can scarce be preserved with any salt. Such parts of animals as are compact and firm are also more easily preserved than such as are loose and porous, which readily admit the air, the grand cause of putrefaction. And for this reason veal and other flesh meats corrupt most quickly, when their cellular membrane hath been blown up by the butchers, which practice is therefore forbidden.

Beef also and other pickled meats are observed to taint soonest nigh the large vessels. And the heads of most animals (especially of cod and other fishes) being very porous, are with great difficulty cured with salt. In curing of animal food, regard ought also to be had to the condition it was in, when slaughtered ; for it can scarce be well cured if the animal was heated by driving, or much bruised before it was killed.

3. It is found more difficult to cure animal food in hot climates, or in very hot weather, than in places and seasons wherein the weather is more temperate ; and the strongest salt is required where provisions are preserved with the greatest difficulty. In those countries which lie between the tropicks, they seldom preserve the flesh of animals except by salting and drying it in the manner before related ; because when they attempt to pickle it, it commonly putrifies before the salt can have a due effect upon it. For the same cause, in temperate climates, the hot season of the year is not esteemed a proper time for salting provisions, except only such kinds as cannot be had at other seasons. It is therefore necessary to use the
strongest

Strongest salt in curing those fish which are taken in summer, or early in autumn; altho' a weaker kind of salt might serve particularly for white fish, if caught at a more temperate season. The places in which those fish are cured often make a stronger salt necessary; for it is much more difficult to cure them on ship-board, especially in the hold (where there is a moist stagnating air²) than at land, where there are cool cellars and other proper conveniences. And not only great heat and moisture, but also intense cold makes the season unfavorable for salting provisions; for in hard frosty weather, the housewives observe that animal food will not take salt, it being so hardened and its juices so congealed by the cold that the salt cannot penetrate it, and is not dissolved by it.

LASTLY, provisions must be cured in a different manner, and with different kinds of salt, according to the uses for which they are designed. For example, beef, herrings, and many other kinds of flesh and fish may be pickled very well for home consumption

² On the banks of Newfoundland they salt vast quantities of cod in the holds of ships, without putting them into casks; and these they call Mud fish.

with any good kind of common white salt ³ ; and, if carefully salted with it only once about the month of October, will keep good and sweet for the whole year in a cool cellar. But flesh and fish so salted are not fit for sea provisions, and would not endure exportation into very hot climates. Those therefore, who are most exact in pickling beef for exportation, after the animals have been carefully slaughtered, between Michaelmas and Christmas, take their carcases as soon

³ It hath been much disputed amongst the proprietors of the several kinds of British salt-works, which kind of white salt was fittest for preserving provisions. The proprietors of the Newcastle salt-works assert, that their salt is the best for this use, as being most approved of at the Victualling-office. The owners of the Lemmington works affirm, that their salt is the strongest and of the largest grain. Many again assure us, that for strength and purity no kind of white salt comes up to the brine salt, especially to that which is made at Droitwich. It may perhaps be more difficult than many imagine, to determine which of these opinions is best supported by facts, since all these kinds of salt differ greatly according as more or less care and skill is used in their preparation. However, I shall presume to remark, that, in general, the British white salt is weak and impure ; and though it may serve to cure provisions after the manner and for the uses here mentioned ; yet, if used alone, will scarce preserve them for long voyages into hot countries ; and further, that either through the bad management or the ignorance of the operators, salt hath often been made as well from brine as sea water, which hath been found wholly unfit for preserving provisions.

as cold, and cut them into proper pieces; and after rubbing each piece carefully with good white salt⁴, lay them on heaps in a

⁴ The method here described agrees pretty well with that which is practised in Ireland in curing beef for naval provisions, and for exportation into the American colonies. The white salt there used is chiefly brine salt, or refined rock salt which they have from Liverpool. Bay salt they have chiefly from St. Ubes and other parts of Portugal; many of their salters will not use French salt, (though much cheaper) because of its dirtiness; and in salting commonly use about equal quantities of white and bay salt.

The white salt used at the Victualling-office in London, is altogether Newcastle marine salt; with which they require certificates upon the oath of the vender, that the salt sold to them was made at Shields or other places nigh Newcastle, and is, at least, three months old. The method there practised of salting flesh for the British navy, is related in the following manner, by the Rev. Dr. Hales *Philos. exper.* pag. 89.

“ They first rub it with white salt only; then put it
“ into brine for five days to drain the bloody part out,
“ for it is the blood that is most apt to putrify: then
“ they pack it in casks, strewing white and bay salt be-
“ tween each laying: then fill the cask up with pickle
“ made of water and salt, boiled so strong as to bear an
“ egg: they put three pounds and an half of salt to a
“ gallon of water. The proportion of salt, pickle in-
“ cluded, is, to an hundred weight of flesh, four gallons
“ and a half of white, and one and a quarter of bay
“ salt.”

The same gentleman tried how far flesh might be cured by injecting a strong brine into whole carcasses of animals by the Aorta. An ox being thus treated, “ two
“ casks of the flesh which was not salted with dry salt,

cool cellar, in a drab with a shelving bottom, where they remain for four or five days, 'till the blood hath drained out of the larger vessels. They then take the pieces, and dry them with a cloth, and rub them for the second time with powdered bay salt. They are then fit to be put up in casks, and much care is used in packing them close, and in strewing between them large lumps of bay salt, as they are put up. When the casks are filled with beef, their heads are fitted in ; and all the vacuities are afterwards filled up with the strongest brine that can be made, which is poured in by a hole in the head of the cask. This hole is afterwards closed up, and the cask is made so tight, that none of the brine can leak out,

“ soon stunk to a very great degree.—The flesh of two
 “ other casks of the same ox, which was salted with dry
 “ salt before it was packed in the cask, being examined
 “ eighteen months after, and a piece of it boiled, it
 “ was judged not fit for men to eat, as its juices were
 “ entirely eat up by the salt, and it fell in pieces like rotten
 “ wood. The mutton of a sheep that was hunted immediately
 “ before it was killed, being injected in the
 “ same manner, and afterwards salted with dry salt, and
 “ kept full six months, proved good and sweet, and not
 “ too salt when first freshened in water.” The same gentleman is of opinion, that this method might be of great use in hot climates, where flesh cannot be preserved by the common methods.

and

and no air can gain admittance. It is found by experience, that beef cured in this manner will keep good and sweet for years in the hottest climates.

THE Dutch, as hath before been observed, use no salt for curing provisions, besides their own refined salt. With it they can preserve flesh and fish of all kinds as well as with the strongest bay salt; and chuse to be at the expence of refining bay salt, rather than to defile their provisions with the dirt and other impurities, with which it commonly abounds.

FROM the foregoing accounts it appears, that various kinds of salt are used for curing provisions; but the salt which may in general be esteemed the best for that purpose, as preserving animal food most effectually, and for the longest time, is that which is the *strongest* and *purest*; and may be known by the following characters, viz.

It is usually concreted into large grains or crystals, which are firm and hard, and in respect to those of other kinds of common salt, the most solid and ponderous; it is not disposed to grow soft or moist in a moderately dry air, to which it must have been exposed a considerable time; its colour is
white,

white, and somewhat diaphanous ; it hath no smell ; its taste is truly muriatic, and more sharp and pungent than that of other kinds of common salt ; being dissolved in pure water it casts up no scum, and deposits no sediment ; being mixed with syrup of violets diluted in water, it heightens its blue colour, and does not turn it either green or red ; and, by the exactest chemical trials, discovers no scratch, no alkaline, bitter, or calcarious salts, nor any other impurities whatsoever intermixed with it.

THE salts which approach nighest to this degree of perfection are the best kinds of bay salt, and the strong Dutch refined salt ; but most of the salt now made for sale is very far from answering to these characteristics, as will more fully appear in the following parts of this performance.

THE

T H E

ART of making B A Y S A L T.

P A R T III.

In which, several methods are proposed for making bay salt in England, and other parts of the British dominions.

I N the foregoing parts of this work, I have briefly related the various methods of preparing salt that now are in use, so far as they are come to my knowledge; and also treated of the qualities and uses of the several kinds of common salt as a condiment, and seasoning to our food. From which short narrative it appears, that the art of preparing salt is not brought to such perfection in the British dominions, as in several other countries, the salt there prepared being unfit for preserving many kinds of provisions. It remains now to shew, that this want of strong salt of British manufacture, proceeds not from any defect of nature,

ture, but of art ; and that if proper skill and industry be used in the British dominions, and due encouragements be there given by the legislature, such improvements may be made in this art, that not only Great Britain, but Ireland also, and the British colonies in America, may be supplied with salt of their own manufacture, proper for curing all kinds of provisions, in quantity sufficient for all their occasions, in quality equal, if not superior, to any foreign salt now made, and at a moderate price. These are truths which I hope will appear evident from the facts and reasonings contained under the following propositions.

L E M M A I.

The quantity of water which annually falls in rain, snow, and hail, is very different in different parts of Great Britain ; there commonly falling almost double the quantity on the western coasts, that falls on the eastern coasts of that island.

ACCORDING to the observations hitherto made, the depth of water which annually falls on the ground, supposing it all to stagnate thereon, would, at a medium, amount
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at Townly in Lancashire to forty-two inches and a half¹: at Plymouth to thirty-one inches²: at Upminster in Essex to nineteen inches and a quarter³: at Widrington in Northumberland to twenty-one inches and a quarter⁴: at Edinburgh to twenty-two inches and a half⁵.

THIS great difference in the quantity of water which falls in different parts of this island is not (as the Rev. Mr. Derham⁶ and others suppose) owing chiefly to the plainness or hilliness of the different parts of the country, but to several other concurrent causes, and more especially to the different qualities of winds in different places, and to the situation which those several places have, with respect to seas, or tracts of dry-land.

THE winds, which blow most frequently in Great Britain, are the south, south-west,

¹ See Mr. Townley's *Obs.* in the *Acts of the Royal Society*.

² See Dr. Huxham in his treatise *De aere & morb. epidem. Plym.* and *Medical Essays*, vol. v. art. iii.

³ See Mr. Derham's *Meteorolog. Obs.* in the *Ph. Transf.*

⁴ *Ph. Transf.* Gray's *Ab.* vol. ii. pag. 45.

⁵ *Medical Essays*, vol. v. art. iii.

⁶ See his *Physico-Theol.* Book iii. chap. v. note L. Also *Ph. Tr.* N^o 286 and 297.

and

and west winds. These are also the warmest winds, raising vast quantities of clouds and vapours, which they drive before them from the great western ocean and Irish sea. The greatest part of these clouds and vapours falls upon the coasts from Land's-end to the north of Scotland. And hence Wales, Lancashire, Cumberland, and other places situated on the western coast, are watered with heavier showers than any other parts of the island. For (as Mr. Townly⁷ formerly observed) the clouds and vapours driven from the sea seldom pass to the opposite sides of the isle, but generally descend in rains and other watery meteors, before they have passed those ridges of mountains which run along the middle of it. So that the south and south-west winds are rainy winds in Lancashire, and all other places on the western coasts, but dry winds on the eastern coasts: whereas; on the contrary, the easterly winds bring rain and snow with them to the eastern coasts, but are dry parching winds on the western coasts of the isle. And this rule takes place even in the narrowest parts of Great Britain, as in the counties of Lancashire, and Cumberland on one side,

⁷ *Ph. Transf.* N^o 208. pag. 53.

and

and Northumberland, Durham, and Yorkshire on the other, where the land winds are the dryest winds, and the sea winds the most wet and moist ; which also holds true in most other parts of the world.

Now as the easterly winds blow more seldom in Great Britain, than the south and south-west winds, and are also colder, and bring less moisture along with them ; therefore the quantity of rain falling on the east coasts is only about half as much as falls upon the west coasts of the island, and the quantity of rain which falls in Kent, Essex, Middlesex, Suffolk, and Norfolk, is probably less than in any other parts of the kingdom. For these counties are the farthest distant from the western ocean ; and the easterly winds are not in them very rainy, as they only blow over a small tract of the German ocean. As to Plymouth, and the south coast from the Land's-end to Dover, the south and south-west winds^s bring thither the largest quantity of vapours and rain ; and for reasons very obvious, the quantity of water which falls there, is less than on the west coasts, and greater than on the east coasts of the kingdom.

^s *Medical Essays*, vol. v. art. iii.

L E M M A II.

The quantity of rain which falls in Lancashire, during the four hottest months of the year, viz. May, June, July, and August, doth not at a medium amount to more than a third part of the quantity of water, which falls in rain, snows, and hail, during the whole year.

HAVING purposely made the calculation from Mr. Townly's observations¹; I find that the quantity of water which fell in Lancashire for fifteen years successively, in the months of May, June, July, and August, was to the quantity falling in the other eight months of the year during that time, in proportion as 20525 : 41595. So that during those fifteen years there fell above twice the quantity of water in rain, snow, and hail, in the eight colder months than there fell in the four hottest months of those years. The same will probably hold true in other parts of the kingdom².

¹ See *Ph. Trans.* N^o 208, or Lowthorp's *Ab.* vol. ii. pag. 44.

² At Padua the rain which fell for six years in the summer quarters, was to the rain which fell in the other

L E M M A III.

The water, which ascends in vapours from the sea, very greatly exceeds that which descends thereon in rain and other aqueous meteors: But the quantity of water, which usually exhales from a given part of the ocean in a given time, cannot with any exactness be determined¹.

FROM the foregoing observations it appears, that the exhalations which supply this island with rain, are brought chiefly from the sea, the winds which blow over land being generally dry winds, and the sea winds commonly bringing rain and vapours.

three quarters of those years as 5825 to 168.828. So that, during those six years, there fell in the summer quarters somewhat more than a quarter part of the rain which fell there in all those years. For $5.825 : 17.475 :: 1 : 3$. See *Ph. Tr.* N^o 421.

¹ The first part of this proposition holds true of the sea in general; though it might prove false, if applied to particular parts of it. For as at dry land, so also at sea, there are some places where it rains almost constantly, and others where it rains seldom or never. For example; in that part of the Atlantic ocean called the Rains, and in the Andes of Peru, it rains almost continually: whereas in Egypt, and in the plain country along the coasts of Peru, and in several parts of the Pacific ocean it rains very seldom; and in some of these places scarce ever.

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Which rule, if extended to other countries, is found more generally true on large continents than in islands. The evaporations therefore arising from the sea must very much exceed the aqueous meteors which fall upon its surface (as Dr. Halley and others have demonstrated;) for otherwise there would not be a sufficient quantity of vapours raised from the sea, not only to supply it, but the dry land also, with rain and other watery meteors.

BUT the experiments made by Dr. Halley and others, with a view to determine the exact quantity of vapours arising from the sea, are very insufficient for that purpose, being only calculated to shew the great power of the sun's heat in raising exhalations; although this power does not extend to any great depth of the ocean, but is exerted chiefly on the superficial waters, and, in these northern climates, only at certain seasons of the year.

BUT there is another heat, whose power hath been little considered, by means of which vast quantities of vapours are continually raised, in winter, as well as in summer, by night as well as by day, from the profoundest parts of the ocean. And without

out due regard had to the effects of this heat, it will not be easy to account for those vapours, which fall in rain and snow in the coldest months of the year. Besides the sun's heat, the subterraneous heat therefore very greatly promotes the exhalation of watery vapours, especially from the deeper parts of the ocean, where this heat is very considerable.

For all observing sailors agree, that on the main ocean, and particularly on the great western ocean, the air is always mild and temperate, and the surface of the water feels constantly warm in the coldest seasons of the year; so that the sailors are able to judge of their approach to land by observing the water to grow colder². And this great warmth of the ocean at its surface, which tempers the winter's cold, doubtless proceeds from hot steams and vapours, which find a quick and free ascent from the profounder parts of the sea. For in those parts of it which are shallow, as on the banks of

² To the greater cold of the land than of the main ocean in these northern climates in winter, may be attributed those colds and catarrhus fevers, which constantly affect sailors after having passed the western ocean, as soon as they arrive at land either in Great Britain or in North America during the winter season.

Newfoundland, the air is found colder, for want of those warm steams and vapours, which cannot so easily and quickly ascend through the solid earth, as through water. And hence those banks are constantly covered with thick fogs; the warm vapours which are brought from the deeper parts of the ocean being continually condensed by the colder air upon those shallow parts; in the same manner that the watery vapours are continually condensed into mists and fogs upon the icy mountains of Greenland during the summer season³. The same country also

3 “ The temperament of the air is not unhealthful;
 “ for, if you except the scurvy and distempers of the
 “ breast, they know nothing here of the many other dis-
 “ eases, with which other countries are plagued; and
 “ these pectoral infirmities are not so much the effects of
 “ the excessive cold, as of the nasty foggish weather, which
 “ this country is very much subject to; which I
 “ impute to the vast quantities of ice that covers the
 “ land, and drives in the sea. From the beginning of
 “ April to the end of July is the foggish season, and
 “ from that time the fog daily decreases. But as in
 “ the summer time they are troubled with the fog, so
 “ in the winter season they are likewise plagued with the
 “ vapour called frost-smoke; which when the cold is
 “ excessive, rises out of the sea, as the smoke out of a
 “ chimney, and is as thick as the thickest mist, espe-
 “ cially in the bays where there is an opening in the
 “ ice. It is very remarkable that this frost, damp, or
 “ smoke, if you come near it, will singe the very skin

furnisheth us with a notable instance of the great power of the subterranean heat in raising vapours even in the coldest seasons of the year. For on the coasts of Greenland, when the surface of the sea is all frozen into ice, if there chances to be an opening therein, the warm vapours, which before were pent up beneath it, arise so copiously, that being suddenly condensed by the cold they appear like smoke arising out of a chimney. This inward heat of the sea hath therefore no dependance upon the sun's heat, but is equal in winter and summer; or even greater in winter, especially where the surface of the sea is then covered with ice; and is so considerable, that in the coldest seasons of the year it continually agitates the aqueous particles, separates them from each other, and converts them into an elastic fluid. In this manner vast quantities of watery vapours are continually raised from the profoundest

“ of your face, and hands; but when you are in it
 “ you find no such piercing or singeing sharpness, but
 “ warm and soft, only it leaves a white frost upon
 “ your hair and cloaths.” Mr. Egede, *Nat. Hist. of Greenland*.

N. B. The skin is probably singed, as observed by the author, by first being relaxed by the warm watery vapour, and then immediately frozen by the cold.

parts of the ocean. So that in estimating the evaporations from the sea, regard should be had to its inward heat, to its depth, and to the bulk of water which it contains, as well as to its surface and the causes which act thereon.

As to the subterraneous heat hath therefore a very remarkable effect in raising vapours from the sea, it may, together with the force of the air and winds, be esteemed sufficient to elevate the greatest part of those vapours, which in this climate fall in watery meteors during the winter season. That the air and winds lick up vast quantities of vapours hath long been observed, but this their effect may probably be hereafter more fully explained by electrical experiments⁴. It is however certain, that the particles of dry compressed air very strongly attract the aqueous particles, and continually unite with them at the surface of the water, and from thence are continually driven away with them by the force of the winds. The winds also considerably promote this operation of the air by agitating the water into waves, and encreasing its surface (often to double what it is when suffered to subside into

⁴ See Dr. Desagulier's *Treatise on Electricity*.

a plain) thus making the contact between the air and water more vigorous and brisk, and in a much greater number of points. And from these reasons, and such experiments as have been made, the best judges have concluded, that at least as much water is exhaled by the air and winds, as by the sun even in the hottest seasons of the year⁵.

Now the ascent of vapours is retarded by the absence of the heat of the sun, and of the subterranean heat, also by a moist and light air saturated with vapours, not agitated by winds, but hanging without motion over the surface of the water ; by rain filling the

⁵ As Dr. Halley and Dr. Borehaave. From the latter of whom the following passage is extracted. “ Tandem, “ non est alia causa, quæ tantam copiam aquæ de “ terra in ærem evehit, quam ventus; quod idem “ eximius Halleus pulchre docuit, quod variis experi- “ mentis ad stuporem usque didici. Dum enim cylin- “ drum cupreum aqua plenum tempestati procellosæ “ exponebam, mirabar quam incredibilis aquæ copia “ parvo tempore diffilaretur: quum statim postquam “ ventus filebat, parum modo in eodem cœli calore “ exhalaret.” *Chemiæ Part. Alt. cap. De aëre.*

“ The surface of water is liked up somewhat faster by “ winds than it exhales by the heat of the sun, as is “ well know to those who have considered those dry- “ ing winds which blow sometimes.” Dr. Halley in *Ph. Tr. abr. by Lowthorp*, vol. ii. p. 110.

air with moisture, and beating down the aqueous particles in their ascent from the earth ; by frosts congealing the surface of the waters and by other causes on which it would be tedious here to insist.

As therefore the causes which promote or retard the ascent of marine vapours are very numerous, and several of them subject to continual variations, and the true effect of others can scarce be determined, as of the subterranean heat ; neither can the quantity of water on which it acts be discovered ; for these reasons, it seems impossible to estimate with any exactness the quantity of vapours which usually arise from a certain portion of the sea in a certain time. The experiments hitherto made for that purpose were generally made upon water set in close rooms, or at least in shady places, where the rain could give no interruption ; but where also neither the sun nor air could have their due effects upon it, and where it could not, as in the deeper parts of the ocean, be much affected by subterraneous heat. The calculations therefore made from such experiments must needs be extremely inaccurate ; so that little certain can be determined from them concerning the evaporations made from the sea, although
they

they may be of use in demonstrating the following proposition which more nearly relates to our present purpose.

L E M M A IV.

The quantity of water which commonly exhales in Great Britain from shallow ponds during the four hottest months of the year, greatly exceeds the quantity of rain which commonly falls on the surface of those ponds during the said months.

THE ponds of the French salt marshes may well be esteemed shallow ponds, such as here supposed; and so may all others, which do not exceed the depth of two feet. In such ponds the water is not much acted upon by subterranean heat; and therefore it is only necessary here to consider the effects of the sun and air upon water contained in them during the four hottest months of the year. And these effects will be much the same, whether the water be exposed to the sun and air in shallow vessels or in such ponds as are here supposed.

THE accurate Kruquius observed, that at Delft in Holland the quantity of water falling

ling on the surface of the ground did, one year with another, amount to about thirty inches; and that about the same quantity exhaled again from water placed there in the open air, but in a calm and shady place. And it is not to be doubted but that double the quantity, or sixty inches depth of water, would have annually exhaled, had it been placed where the sun and winds could have had their due effects upon it.

¹ DR. Halley found by exact experiments made at London, that water placed there in a close room, where neither the winds nor sun could act upon it, exhaled only the depth of eight inches during the whole year. He observes, that “when once the surface
“ of the water is invested with a fleece of
“ vapours, the vapour rises afterwards in
“ much less quantity. And that when the
“ air was still from wind, much less was
“ evaporated than when there blew a strong
“ gale, although the experiment was made
“ in a close room.” And makes no doubt,
“ that, had the experiment been made where
“ the wind had come freely, it would have
“ carried away three times as much water

¹ See his *Exp.* in the *Ph. Tr.* N°. 212. or *Lowthorp abr.* vol. ii. p. 3.

“ without the assistance of the sun, which
“ would perhaps have doubled it.”

So that, according to his calculations, about the depth of forty eight inches exhales at London, in the open air, from the surface of water during the whole year.

FROM the same experiments it appears, that the evaporations in May, June, July, and August, which are nearly equal, are about three times as great as in the months of November, December, January, and February, which are likewise nearly equal. And having purposely summed up the evaporations, which he has set down as made in the four months of May, June, July, and August, I find them to the evaporations of the other eight months of year in the proportion of 85575 to 77345. So that the evaporations made in the four hottest months of the year, were more by a tenth part than those of all the other eight months.

SUPPOSING therefore that equal quantities of vapours exhale from shallow ponds in the four hottest months, and in the eight colder months of the year ; and that a third part of the water, which annually falls in rain and other aqueous meteors, falls in the four hottest months : Then if, according
to

to Kruquius's observations in Holland, sixty inches of water exhales during the year in vapours, and thirty inches again fall in rain, thirty inches will exhale in the four hottest months, and only ten inches will fall; so that an excess of twenty inches of water will arise, more than will fall during those four months².

IF again we make use of Dr. Halley's estimate, and suppose that forty eight inches of water annually arise in exhalations from the surface of ponds at London; and if (agreeable to observations) we allow twenty one inches of water to fall there in meteors during the whole year; then seventeen inches of water will there exhale from the surface of ponds more than is received into them in rains during the four hottest months³. But in the most rainy parts of England, where $4\frac{2}{3}$ or fourteen inches of water may be supposed to fall during the four months above mentioned, then, if in that time twenty four inches of water should be found to exhale, only $24 - 14 =$ or ten inches of water will in such parts exhale from ponds, more than descends during the said four months³.

² For $\frac{60}{2} - \frac{30}{3} = 30 - 10 = 20$.

³ For $\frac{48}{2} - \frac{21}{3} = 24 - 7 = 17$.

BUT

BUT all these calculations of the evaporations from ponds during the four hottest months are probably short of the true quantity. For it has been observed in France, that in exceeding hot weather water exposed there to the sun and air, will lose an inch of its depth in twenty four hours. And from experiments made by Dr. Halley it appears, that sea water of the same temperature with the air in the hottest weather in England, placed in a close room, lost a fifth part of an inch in twenty four hours; and no doubt, if agitated by the wind, would have lost at least triple that quantity, or three fifths of an inch, in the same space of time; and should the said evaporation continue constant during the four summer months, it would in that time amount to $73\frac{4}{5}$ inches, which is more than thrice the quantity allowed in the above calculations.

P R O P. I.

In several parts of England large quantities of bay salt may be extracted from sea water during the hottest months of the year; by receiving the salt-water into ponds, and suffering its aqueous parts thence to exhale
by

by the heat of the sun, and the operation of the air and winds.

FOR if in some of the warmest and least rainy parts of England a pond, at a moderate computation, usually loses seventeen inches depth of water in exhalations during the four hottest months, more than it receives from the heavens during the same time; then if a firm and tight pond be filled with sea water to the depth of sixteen inches in the beginning of May, all that water, together with the rains that fall into the pond, will be usually thence exhaled by the end of August, and the bottom of the pond will remain covered with a crust of salt; as in summer may be observed on the sea shore in hollows of rocks, where small quantities of sea water have been left by the tide, or, as is more observable in the salinæ before described¹, from which vast quantities of salt are annually collected.

THE evaporation of sixteen inches depth of water by the sun and air, is here supposed to take up four months: in rainy summers it may require a longer time, or even may not be effected during the whole

¹ Part ii. Chap. ii.

summer.

summer. But it also often happens in many parts of England, that not an inch depth of water falls in a whole summer month, and the weather in such dry seasons being usually very hot, half an inch depth of water may then be supposed to evaporate every day ; so that the whole evaporation of sixteen inches depth of sea water will, in such a dry season, be performed in thirty-two days.

THE following calculation may give some idea of the quantity of salt, which may thus be extracted from ponds covered with sea water to the depth of sixteen inches. A cubic inch of pure water weighs about 256 grains ; and if we suppose that the sea water on the coasts of England contains $\frac{1}{32}$ part of salt, then each cubic inch of sea water will contain $256 \times \frac{1}{32} = 8$ grains of salt ; and sixteen cubic inches $16 \times 8 = 128$ grains. There would therefore remain after the evaporation of sixteen inches depth of water 128 grains of salt upon every inch square of the pond, and upon every yard square 21 lb. 9 oz. 288 pwts. averdupoize weight ; and upon every statute acre of such ponds 104544 lb. or 1245 bush. 64 lb. of bay salt². The price

² Bay salt now costs at London, exclusive of excise, four shillings and four pence per bushel.

of which, if sold for a shilling a bushel, would be 62l. 5s. 9d. so that ground rightly prepared might thus be made to produce annually an excellent rich crop of salt, which would not require more labour and expence than is necessary for crops of far less value.

BUT as the above method of preparing bay salt from sea water, is tedious and subject to miscarry by rains, and the salt so made could scarce be collected without mud³, and the calcarious earth, and other gross ingredients of sea water would remain mixed

³ Mr. Boyle found the specific gravity of a hard lump of sea salt to that of common water almost as 2:1. But the specific weight of an hard lump of sal gem. is to that of water nearly as $\frac{1}{28}$:1. If therefore (as before supposed) each square inch of the bottom of the pond was covered with a crust of salt weighing 128 grains then the said crust would only be a quarter of an inch in thickness. For 250. the number of grains in a cubic inch of water, being divided by 2, gives 128. So that if a cubic inch of water be divided into two equal parts by a plain parallel to its base, each of those parts will weigh 128. and the altitude of each will be half an inch. But the altitude or thickness of a crust of salt upon the same base, and also weighing 128. will only be $\frac{1}{4}$ of an inch; seeing that the specific weight of salt is double to that of common water. But so thin a crust of salt could scarce be separated from the bottom of the pond, without a large proportion of mud and other impurities adhering to it.

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with it, it would not therefore be adviseable to make a trial of this method; especially as the following may easily be put in practice, which is far more commodious, expeditious, and certain.

P R O P. II.

In several parts of England large quantities of bay salt may very commodiously be extracted from sea water, after the same manner that is practised in France, and in other parts of Europe.

THE parts of England most proper for this work are those which are the warmest and least rainy, as on the coasts from Dover to Yarmouth: although the same work will succeed very well in other places¹. For if such large quantities of bay salt can be prepared in France as are sufficient for the whole annual consumption of that large kingdom, and of all those nations who purchase it from thence, and that in so short a time as one fortnight of good weather; why may not large quantities be prepared in the above-mentioned, and several other parts of England, during the whole summer season? if

¹ Particularly on the coast from Dover to Land's-end.

salt can be extracted in France, even in the night time, why may it not in England during the day? If bay salt can be made in considerable quantities, and to profit, in the sun pans of Hampshire², why not in larger quantities, and to much greater profit, in salt marshes, which are much more artful and commodious?

THERE are several parts of the English coast, which do not lie above two or three degrees farther north than the coasts of Britany, where such vast quantities of bay salt are made; and particularly the coasts above pointed out, where this salt is chiefly wanted for curing fish and naval provisions; where the heat of the sun is not much less than on the coasts of Britany; where the winds and air will also have the same effect as in Britany; and where, in all probability, there is considerably less rain to retard the operation, than on the French coasts. So that it is not likely that this work would proceed much slower in England than in France.

BUT, that this may more plainly appear, let it be granted, that the heat of the sun is so much greater in Britany than on the coasts

² See the foregoing accounts of the method of making bay salt in France and Hampshire.

of Essex and Suffolk, that water will exhale even twice as fast in the first, as it does in the last mentioned places, during the summer months. Allowing even this supposition, it will be no difficult matter to shew, that such an inconveniency might be overcome; and that, under such circumstances, as much salt might be prepared in an English salt marsh as in one in Britany, and with no great difference of expence.

SUPPOSING therefore, that from a surface of one yard square, as much water exhales in Britany, as from a surface of two square yards in England. And if we farther suppose two cylindrical vessels of equal capacities, but so formed, that the surface of the fluid in one, is double to the surface of the fluid in the other, and that these vessels, when filled with water, are placed, that with the larger surface, in England, and that with the smaller surface, in Britany: then, according to the first supposition, equal quantities of water will exhale from those two vessels in equal times, and both vessels, as they contain the same quantity of water, will become empty in the same space of time. And if the water in both vessels be of an equal saltness, an equal quantity of

O 2

salt

salt will remain in each vessel, after all the water is exhaled.

IT is therefore very possible to answer all the requisites in the following problem, viz. *By a moderate heat of the sun, and the force of the air, from a given quantity of water to exhale a certain quantity given, in a given time* ; for this may be done by proportioning the surface of the water to the force of the sun and air, and to the quantity of water required to be exhaled in the time given.

SHOULD it then be required to make the same quantity of bay salt at a salt work in England, as is usually made at a salt work of the same kind on the coast of France ; that this may be done, it is necessary that equal quantities of sea water (supposed at both places of an equal saltness) should be received into both works, and that the evaporation should be equal in both. Which would be the case, if the water in the salt work in England be exposed to the sun and air with a greater surface than in the French work ; so that this greater extent of surface may compensate for the less force of the sun's heat : or, in other words, so that the whole surface of the two salt works may be in a reciprocal

reciprocal proportion with the evaporations from equal portions of their surfaces. For example; if the evaporation from a certain part of the French salt work, be double to the evaporation from an equal part of the English work, then must the surface of the English work be double the surface of the French work. And since an equal quantity of salt water or brine is supposed to be contained in both works, therefore the English pits must in such case have only half the depth of water in them, that is in the French pits. So that in the reservoir, where there is ten inches depth of water in the French work, there must be only five inches depth in the English work, and in the shallower pits in the same proportion.

THE foregoing calculations are made upon a supposition, that it is dry weather, during the whole time that the water is evaporating; but as in the salt marshes this business is frequently disturbed by rains, it is necessary, in practice, also to make an allowance for the water received from the atmosphere into the salt marsh during the evaporation; and upon that account, to enlarge the surface of the English work yet considerably farther: For supposing only

the same quantity of rain to fall into the English, as into the French salt work, as the evaporation is supposed slower upon a certain part of the English work than upon an equal part of the French work, it is necessary, that the water falling into the first work be spread over a larger surface, than that which falls into the latter, in order that in both it may be exhaled in equal times. But as the surface of the English work is supposed larger than the surface of the French work, more rain may probably fall into it than into the French work; so that it may be necessary to extend the surface still farther; and so to evaporate the excess of water, which it receives from the atmosphere.

How far it may be really necessary to extend the English work farther than a French work of the same capacity, in order to make an equal quantity of salt in each of them, can only be ascertained by proper experiments. But all circumstances being duly considered, we may reasonably conjecture, that, in several parts of England, if a salt marsh was formed, whose surface was only a fifth or a sixth part larger than that of a French salt marsh, as much salt, at least, might be prepared in the English marsh, as
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in that of France. And if we consider the situation of the French coast, how it must be watered with heavy rains from the western ocean, we cannot suppose that less water falls there in rain and other aqueous meteors, than on the coast about Plymouth, which at a medium is thirty-one inches in the year; whereas on several of the warmest parts of the English coasts there does not annually fall above twenty inches. So that during the summer season more water will probably fall into the French salt marsh than into one of a fifth part larger surface, situated on the coasts of Essex, Norfolk, or Suffolk.

IF therefore it should prove true in fact, as in all probability it will, that as much salt may be extracted from an English salt marsh, as from one in France, when the surface of the former is one fifth larger than that of the latter: then, in order that both works may contain an equal quantity of brine³, it will be necessary, that in the re-

³ The following theorem may be of use in determining the depths of the several ponds, so that the two salt marshes may be made to contain equal quantities of brine, viz.

*As the surface of the broader pond in the English marsh,
is to the depth of the narrower pond in the French marsh;*

reservoir where the salt water is ten inches deep in France, it be eight inches one third in England; and the salt pits where the brine is one inch and an half deep in France, it must be one inch and a quarter deep in England⁴. And care should be taken to lay the bottoms of the several pits in such a manner, that the depth of the brine in them may answer to the above-mentioned proportions.

THE English salt marsh must be made larger or smaller as occasion requires; so that care be taken to observe the above, or

so reciprocally the surface of the narrower, is to the depth of the broader.

Thus, if the surface of the French reservoir be a hundred yards square, its surface will then contain 5760000 square inches. And the English reservoir $5760000 \times \frac{5760000}{5} = 6912000$ square inches. Then as the French reservoir is ten inches deep, according to the above theorem, $6912000 : 10 :: 5760000 : 8\frac{1}{3}$. And the product of the two extremes will be found equal to that of the two means, which give the solid contents of the French reservoir in cubic inches.

⁴ Supposing the French salt pits ten inches square, their surface will contain a hundred square inches; and the surface of the English salt pits (being one fifth of an inch larger) 120 square inches: then, $120 : 1\frac{1}{5} :: 100 : 1\frac{3}{4} = 1\frac{3}{4}$.

The same proportion will hold good, if the surface of the French salt pits be supposed of any other magnitude.

such

such other proportion in the dimensions of its several parts, as by experience shall be found most proper. In general, it is necessary that the reservoir and brine ponds be of a sufficient magnitude to furnish the salt pits with a constant supply of the strongest brine, in the place of that which is continually reduced to salt.

P R O P. III.

Bay salt may be extracted in England from sea water in larger quantities, and with more certainty, than by the foregoing method, if care be taken to preserve the brine contained in the salt pits from being diluted with rains, and to promote the evaporation of the water by several artificial means, which may easily be put in practice.

THE above related method is easy and practicable; and we find one much less commodious succeed to advantage on the coasts of Hampshire, where there falls one third more rain than in several other parts of the English coast. But those who are desirous of preparing more salt than can be done by the foregoing methods, and would have their work less interrupted by rains,
and

and would chuse to have their brine lie deeper in the salt pits, and to have the salt formed into large cryftals, may for thefe and other purpofes have recourfe to the following methods.

FIRST, it will be proper to make all the falts pits of the marfh, in one long row, extended from eaft to weft¹, and for each pit to make covers of thin boards, or rather of coarfe canvas, or fail-cloth, ftretched on frames of wood, and painted white. Thefe covers muft all be fixed with hinges to ftiong pofts and beams on the north fide of the pits, fo that they may be let down and drawn up with cords and pulleys, or by fome other contrivance, fomewhat like draw-bridges. Thefe covers thus fixed may be let down over the pits like a fhed or pent-houfe, in rainy weather; and in dry weather may be erected almoft to a perpendicular, but inclining a little towards the fouth; fo as to form a wall with a fouth afpect. And thus may ferve a double ufe, as coverings for the

¹ It will be alfo neceffary to make the bottoms of the falt pits of alabafter, or fome other ftiong cement that will not eafily break up; by which means the falt may be drawn white and pure, as in Spain and Portugal, and not dirty and grey, as in the French marfhes.

pits in wet weather, and as reflectors of the sun's heat upon them in dry weather. For when they are let down they will prevent the rain from mingling with the strong brine contained in the salt pits ; and when they are drawn up in sun shiny weather, they will strongly reflect the rays of the sun upon the brine contained in the pits, and thus greatly promote the evaporation of its aqueous particles. The hinges on which the reflectors turn may be fixed about eight or ten inches from the ground. By which means, when the reflectors stand upright, there will be an opening left beneath them, through which the air will continually flow in a brisk current, and greatly encrease the evaporation of the water.

IN order also that no diluted brine may flow into the salt pits during rains, it will be necessary at such times to stop the narrow winding channel leading to the pits, by a little sluice. This channel also must be made very narrow, and every where covered over with boards. And there must not be a pond at the entrance of the salt pits, as in the French marsh, but only a narrow covered trench, running parallel to the side of the pits which is opposite to the reflectors. And the pond, which

which forms the entrance of the pits in the French salt marsh, must in this be detached from them ; and instead thereof must be formed a fourth brine pond, communicating with the third by a long narrow channel.

IF these contrivances should be reduced to practice in England, the salt will probably crystalize there much faster than in the French salt marshes. And the brine may be kept as deep and even deeper there than in the French salt pits. In which case the English salt marsh will require fewer pits than in the method proposed in the foregoing proposition. And if a shower or two of rain chances to fall, the operation will only be retarded while the rain continues ; whereas in the French open work, such a quantity of rain falling often puts a stop to the work for two or three days, as all the fresh water that fell must again be exhaled, before any salt can be formed.

BUT in order to prevent the weaker brine from being diluted with rains ; and in order also to provide a sufficient quantity of brine which may always be ready to supply the place of that which crystalizes in the salt pits, it may be necessary to dig in the earth
four

four cisterns adjoining to the brine pits above proposed, which may be made tight at the bottom and sides with brick and clay, into which the brine in the salt ponds may be admitted when the rainy weather comes on, so that the brine of different degrees of strength may run into separate cisterns, and may again be pumped out of them into the several ponds from which it was drawn, as soon as the weather grows dry, and the fresh water, which fell into the pits, hath by proper drains been first discharged out of them.

As to the salt water in the reservoir, if it should not be found necessary to preserve it from rains in cisterns; when so much rain falls, as to make it fresher than sea water, it may be let out, and sea water admitted into its place. And in order to promote the evaporation, and to make the salt water in the reservoir fitter to supply the first brine pond with brine of a due strength, it may be proper, by means of a small fire engine, continually to force up the salt water in the reservoir as often as occasion requires, and by means of a diverger fitted to the engine to make it descend again into the reservoir like a shower of rain; by which means the evaporation

poration of the watery vapours will be greatly promoted, after much the same manner as is practised at several salt works in Germany where the brine is very weak.

AND thus by augmenting the force of the sun's heat, and of the air, and by promoting the evaporation of the watery vapours, and by preventing the brine from being diluted with rain, it is very probable, that during the summer season double the quantity of salt might be prepared at an English work with these contrivances, that is now usually prepared at a French salt marsh of equal magnitude.

P R O P. IV.

In several parts of England large quantities of excellent bay salt may, with great ease, be prepared from the natural brine of salt springs, and also from rock salt dissolved in weak brine, or sea water.

IN Cheshire, where they have natural brine almost fully saturated with salt, if they should think proper to extract bay salt from this brine, it may be pumped directly into salt pits (without any previous preparation) there to be wrought with reflectors, as described
under

under the foregoing proposition. Only, if there be any ochre or mud mixed with the brine, it may be proper to draw it first into covered reservoirs or cisterns, there to stand till these impurities are subsided, and from thence to let it out into the salt pits as occasion may require.

BUT if, as it commonly happens, the brine be not fully saturated with salt, then it may be exposed to the sun and air in brine ponds with reflectors fitted to them until it be reduced to a saturated brine, after which it may be received into the salt pits. Or else the weak brine may be fully saturated with rock salt, where that can be had cheap, or even with white salt, if due encouragement be given by the legislature. Or where there is plenty of rock salt and no brine, fresh water, or sea water (if it can be conveniently had) may be saturated with it, and reduced to bay salt in salt pits with reflectors as before described.

THUS large quantities of bay salt may be made from natural brine at one operation, as is practised at the isle of May and in several parts of the West Indies. Of the quantities which can thus be extracted some
con-

conjectures may be made from the following calculations.

SUPPOSE a falt pit sixteen feet square. A work confifting of eighteen pits of the fame fize, placed all in a row, will be ninety five yards long, and will be fomewhat larger than the falt pits of the French marfh before described. The area of each of thefe pits will be two hundred and fifty fix fquare feet, and if they are covered a quarter of a foot deep with brine, then each pit will contain fixty four cubic feet of brine. But from ¹ Dr. Baynard's experiments, a cubic foot of common water weighs exactly feventy fix pounds troy. Therefore fixty four cubic feet weighs $64 \times 76 = 4864$ pounds troy. Suppofing therefore each pound, or twelve ounces, of brine to contain three ounces and an half of falt, then 4864 pounds of brine will contain 17024 ounces or 1064 pounds averdupois of falt, and eighteen pits of the fame dimensions 19152 pounds, which is exactly 228 bufhels of falt, each weighing eighty four pounds averdupois.

BUT as a pound troy, or twelve ounces, of water, will diffolve more falt than three ounces and an half; if therefore the pits be

¹ See his *Exp.* made at Oxford; in the *Ph. Tr.*

filled

filled to the depth of three inches with fully saturated brine, more salt will be contained in them than here supposed. If it therefore be granted, as many affirm, that a gallon, ale measure, of the strongest Cheshire brine, which is almost fully saturated, holds three pounds averdupois of salt (which is very nigh a pound of salt to three pounds of water) the $7059\frac{1}{7}$ gallons of fully saturated brine, supposed as before to be contained in the eighteen salt pits, will hold somewhat more than 21177 pounds, or two hundred and fifty two bushels nine pounds of salt.

IN order to estimate the time required to prepare the above quantity of salt, let it be supposed (as with great reason it may) that in dry summer weather, half an inch depth of water will, one day with another, exhale from the salt pits when wrought with reflectors. Then three inches depth, the quantity of water contained in the brine, will be exhaled in six days; so that at the end of six days all the salt, contained in the brine, will remain dry at the bottom of the pits; which, according to the first supposition, is two hundred and twenty eight bushels of bay salt; and, according to the second, somewhat more than two hundred fifty two bushels. And if we divide those

quantities by fix, the number of days in which all the water is exhaled, we shall find that, according to the first supposition, thirty eight bushels, and, according to the second, somewhat more than forty two bushels of bay salt may be daily prepared in dry summer weather, in a work of the above dimensions.

THE same calculations also shew the quantity of salt, which may be prepared from sea-water in a salt marsh, where the pits are of the dimensions above supposed; for in both cases the salt pits must be kept constantly filled with a fully saturated brine. But if only half the quantity here supposed, viz. twenty one bushels, or 1764 pounds of salt, can be made every dry summer day in a salt marsh of the above dimensions, it is as much as is commonly made every day from brine in a saltern whose boyler contains eight hundred gallons.

P R O P. V.

Bay salt may be prepared in England by the foregoing methods at a very moderate expence, equal in goodness to the best foreign bay salt, and in quantity sufficient for the consumption of all the British dominions.

IF in the first place, we compare the French salt marsh with the English saltern for boiling white salt, we shall find the expence of making the former much less than that of making the latter ; in which the expence of boiling-houses, hot-houses, furnaces, salt pans, &c. is very considerable ; and which also frequently require large sums to be laid out on them to keep them in repair ; whereas the French marsh requires very little repairs. Besides, the expence of coals or other fuel is very great in the English saltern, which is all saved in the French bay salt work ; and the expence of labour will be more in proportion to the quantity of the salt made in the English white salt work than in the French salt marsh. And for these reasons ; though the French bay salt is better than the English boiled salt, yet it can be made for seven or eight shillings a tun, which is little more than one third of the price for which white salt can be made in the most commodious parts of Great Britain.

IF again we compare the French salt marsh with the English marsh, as proposed under Prop. the second, we shall find that where the situation is equally convenient,

difference of the expence in making them will be very inconsiderable. For as the partitions between the salt pits, and the trench and sluice which admit the sea water, and the walls between the ponds, are the most expensive parts of the work ; if therefore the English work be one fifth part more in surface than the French work, it will not require above one tenth part more expence to make it, than to make the other. And this small difference in the prime cost of the two works, will occasion but a very trifling difference in the expence of making salt in them ; especially as the works, when finished, will require little repairs for twenty or thirty years.

THE expence of the English salt marsh will indeed be considerably increased by the additional contrivances proposed under the third Prop. The most expensive of these will be the reflectors, which I am informed by a good judge, if made of strong sail cloth stretched on frames, and painted white, and properly fixed to posts, so as to cover eighteen pits of sixteen feet square, might probably cost 50/. or at the most 60/. And should all the other contrivances cost 60/. more, or even double that sum ; this addi-

additional expence would be very quickly accounted for in the profit of the work, as it is probable that double the quantity of salt might be made with these contrivances, that could be made without them. And the additional labour, which these contrivances would occasion, would make very little increase of expence, as it would all be performed when no salt is drawn, and consequently when the labourers have little else to do.

As to the work proposed under Prop. IV. for making bay salt from natural brine; twice as much salt might be prepared in it in one day (according to the foregoing calculations) as is usually made in a Cheshire saltern, whose pan contains eight hundred gallons. Although the saltern would require much more money to erect it, and to keep it in repair, besides the expence of coals; which is the heaviest article, costing oftentimes above two thirds of the value of all the salt prepared with them.

ALL these things therefore considered, it may with reason be presumed that bay salt may be made in several parts of Great Britain, nearly as cheap as it is now made in France. And as the French and

other foreign salt must be charged with a considerable freight when brought to the British market, it is very probable that bay salt made in great Britain might be afforded cheaper there than French or any other foreign salt; especially as there is 1 s. 1 $\frac{1}{3}$ d. paid more in duties for every half hundred weight of foreign salt, than for the same quantity of British salt consumed in England¹; which ought to be considered as a bounty to the British manufacturer of bay salt. Moreover, the law now allows three bushels duty free, for every wey (or forty bushels) of British salt carried coast-wise; which allowance will not only make up for the waste in carriage, but will also pay the expence

¹ By the laws as now established, white salt and other salt of British manufacture consumed in England pays a duty of 3 s. 4 d. per bushel, weighing fifty six pound.

But bay salt, and other foreign salt there consumed, pays a duty of 6 s. 8 d. per bushel, weighing eighty four pound. So that fifty six pounds of foreign salt pays 4 s. 5 $\frac{2}{3}$ d. in duty; from which 3 s. 4 d. being deducted, there remains 1 s. 1 $\frac{1}{3}$ d. which is paid for fifty six pound of foreign salt more than for the same quantity of British salt consumed in England. In both cases an allowance is made for prompt payment. In Scotland the excise upon British salt as well as foreign salt there consumed, is only half of that paid in England.

And all salt applied to curing such fish as is exported to foreign markets, is in both parts of the united kingdom free from duty.

of carrying the salt to market, to most parts of England. The laws therefore, as they now stand, are extremely favourable to the British manufacturers of bay salt, who, together with the public, would, in all probability reap great advantage by making salt works, such as before proposed. And such numbers of these works might be made at proper places along the British coasts, and nigh brine pits where fuel is scarce, as would afford bay salt enough for all the occasions of Great Britain; and might even furnish an article for exportation in those ships which are sent from thence empty to Denmark, Norway, and into the Baltick, for hemp, flax, iron, timber, and other commodities of those countries.

IT remains now to shew, that bay salt, thus made in Great Britain, will, answer all the purposes of foreign bay salt, and will be equally good for curing fish and flesh, and for all other culinary uses.

As to the sea salt, no one will call this in question, since it is made from the same water as foreign marine bay salt, and the method proposed for making it appears to be at least as good as that which is practised by foreigners. And it hath already been found

by experience, that bay salt made in Hampshire is not inferior to foreign bay salt for the abovementioned uses. And where natural brine is sufficiently pure, as at Droitwich, there is no doubt but that an excellent bay salt might be made from it at one operation, as is practised in the isle of May, and in other hot countries. But if there be much calcarious earth, or other earthy impurities mixed with the brine, as in Cheshire; such brine will afford a better salt if it is only of a moderate strength, so that it may remain a considerable time in brine ponds, there to mellow, and to heighten into a fully saturated brine, and to depose its earthy impurities, which would be very prejudicial to the salt if mixed with it, as will be more fully explained hereafter.

P R O P. VI.

In several of the British colonies in America, bay salt might, with little expence and trouble, be prepared from sea water, in quantities sufficient to supply the American fisheries, and all the other occasions of those colonies, so as to become a considerable branch of their trade.

It

IT seems a truth deserving the consideration of every friend to Great Britain, that its colonies in America might be made capable of furnishing it with almost all kinds of natural commodities, which it wants of foreign production; as wine, oil, spices, tea, silk, hemp, iron, and other metals. Salt is also a commodity, which those colonies might be made to yield in great abundance; and is so much wanted for their own consumption, and so necessary for the support of their fisheries, that it seems strange that its manufacture should have been there so long neglected; especially as it might be made in most of those colonies at a very small expence. For all the sea coasts of Georgia, Carolina, and Virginia, and the isles of Bermudas, lie between 31 and 38 degrees of latitude; so that their most northern parts are eight degrees nearer the line, than those coasts where the greatest part of the French salt is made. The grapes, which in France are not ripe till September, in Carolina are ripe in June, or the beginning of July. And in all those colonies the heats in summer are more excessive than in any part of the bay of Biscay, and the draughts oftentimes very distressing. So that there is no danger of
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wanting either sun or fair weather for making salt on all that vast extent of coast ; and even much farther northwards, as in New York, New Jersey, and New England. In such parts therefore of these coasts as have a convenient situation, marine bay salt might be made with great ease, and in very great abundance, and probably at as cheap a rate as in any other part of the world ; so that those colonies might be supplied with salt of their own manufacture, at a much cheaper price, than they have it from the Cape de Verde isles, and Salt-Tortuga ; and would never more be put to the necessity of bringing it from Sardinia and Portugal, as they now are in this time of war. For it is now found too hazardous an undertaking to go to the isle of May, or Tortuga, to make salt, as ships lying so long in open roads are too much exposed to the enemy. And in times of peace the length of the voyage, the danger of the seas in open roads, the expence of making and shipping the salt, and the uncertainty of getting a loading, must make the salt from those islands come much dearer to the British colonies, than that of their own manufacture ².

² In times of peace bay salt is sold in bulk in the Bri-

As to Jamaica and the Caribbee islands, which lie between the tropics, the heat of the sun is there so intense, and the weather so settled during the greatest part of the year, that those colonies might, with a very little trouble and expence, be supplied with marine bay salt of their own manufacture.

If therefore in future times, the British dominions, either in Europe or America should want bay salt of their own manufacture, fit and sufficient for all their occasions, and at as a cheap or even a cheaper rate than they now have it from foreign markets, it may be concluded that the scarcity proceeds, either from a want of industry in the British subjects, or else, for want of proper encouragements from their legislature.

tish colonies in North America, at a medium for about 15*d.* per bushel (and cannot well be afforded for less, as I am assured by gentlemen of experience) and now in time of war above double that sum is paid for it, and it can scarce be had at any price ; although it might be made in those colonies for 4*d.* per bushel in times of war, as well as in times of peace.

THE

The ART of preparing
WHITE SALT.

PART IV.

In which some methods are proposed for preparing white salt fit for preserving provisions.

ALTHOUGH it may be presumed, that if the rules before given be reduced into practice, the subjects of these kingdoms may be supplied with excellent bay salt of British manufacture, fit and sufficient for their occasions ; yet nevertheless, I am desirous of proposing several improvements that may also be made in our methods of preparing white salt ; which, if brought into use, may probably be of advantage not only to private undertakers, but also to the public. From what hath before been observed, it appears, that two very different kinds of white salt are required ; the one for
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the use of the table, and the other as a condiment for provisions. Its whiteness, dryness, and the smallness of its grain, are the properties which chiefly recommend the first kind ; and its great strength and purity, the latter. It is this strong and pure kind of white salt which is wanted in the British dominions ; and it is therefore my principal design here to consider how this defect may be supplied ; although instructions will at the same time be given how to prepare table salt, not only better in quality, but also at a less expence than it is now prepared by the common methods.

L E M M A I.

In the common processes for making white salt, the salt is deprived of a considerable part of its acid spirit by the violent boiling used in its preparation.

THE Rev. Dr. Hales, to whom the world is indebted for many excellent discoveries, in the method which he hath published of making salt water sweet and potable, hath given us the following experiments.

HE distilled sea water to a driness in glass vessels, dividing the water as it came

* See his *Philos. exper.* pag. 12, 13, 14.

over into nine different portions. He observed that the first portion, which arose till the water began to boil, was pretty well tasted; but the seven portions which came next over while the sea water in the retort was boiling, had all of them a flat, unsalt, nauseous, dry, adust taste. The ninth portion, which came over last, till the salt in the retort was distilled to a driness, was more harsh and disagreeable than any of the rest, tasting more of a kind of spirit of salt; but none of them had any taste like bitterness or bitumen. Half a spoonful of each of these nine portions of distilled water being put into separate glasses, to each glass was added two drops of a solution of pure silver made in aqua fortis, and diluted with spring water. This solution immediately caused white clouds in the clear distilled water, which were least in the first portion, and nearly the same in all the others, except in the last, which had whiter and thicker clouds than any of the rest. And these white clouds plainly discovered the distilled water to be impregnated with spirit of salt, by means of which the silver dissolved in the aqua fortis was precipitated.

By

² By other experiments, the same learned gentleman found that the spirit of salt arises in greater quantities in proportion as the distillation is carried on farther³. He also observed, that when sea water was distilled before it had corrupted, a third part of the water, which first came over, had no very considerable quantity of spirit of salt mixed with it, but might be used instead of fresh water. For though when first distilled, it gave white clouds with the solution of silver; yet after standing in flasks for three months, it no longer gave any white clouds, nor other marks of acidity. But the two remaining thirds of the water, which were last drawn off, after standing three months, still continued to taste tart and rough, and gave manifest clouds with the before-mentioned solution.

⁴ He also discovered that sea water after putrefaction, might be distilled with a boil-

² *Philos. exper.* pag. 38.

³ The same work, pag. 39, 40.

⁴ It seems reasonable to believe, that when sea water is evaporated by a boiling heat, it emits the acid fumes of salt sooner and in larger quantities when fresh than after a putrefaction; because while it is fresh and retains its viscosity, it requires a stronger heat to disentangle its aqueous parts, and to reduce them into vapours. And by this stronger heat the acid spirit is also
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ing heat, till four fifths of it was come over before any considerable quantity of the spirit of salt would arise. But when the distillation was continued until the salt in the retort remained dry; that fifth portion of the water which last arose, was so strongly impregnated with spirit of salt, that it tasted plainly acid, and not only precipitated silver from the before-mentioned solution, but also gave greater marks of acidity by turning syrup of violets red; which several other portions of distilled sea water would not do, although they were sufficiently impregnated with the saline spirit, to give white clouds with the solution of silver, as before related.

^s THE excellent Mr. Boyle assures us, that when he distilled sea water in a glass head and body with a moderate heat, till a consi-

derable part of the water is evaporated; but when, by putrefaction, the water hath lost its viscous quality, it boils, and this off in vapours with a less degree of heat; therefore no acid spirit is raised till four fifths of the sea water is exhaled; (see Dr. Hales *Ph. exp.* pag. 31.) but then, the water remaining, being greatly loaden with salt, and thereby made thick and ponderous, it contracts such an intense heat in boiling, as is sufficient to separate a considerable quantity of acid spirit from the salt, and to raise it along with the watery vapours.

^s See his *Phil. works* abridged by Dr. Shaw, vol. iii. pag. 220.

derable

derable portion of it was drawn over ; he could not find that this water, either by its taste, or a more chemical examination contained any thing of salt in it ; although it is well known, that he first applied the above-mentioned solution in trials of this kind, and doubtless made use of it upon this occasion. These his experiments do no ways disagree with those of the Rev. Dr. Hales before related ; for had Mr. Boyle applied a more violent heat, he would doubtless have found the distilled water impregnated with the acid fumes of salt, as in Dr. Hales's experiments.

AND that sea water, when distilled in large alembics, after the common method, with quick fires, doth part with a considerable quantity of acid spirit, was long ago known to Mr. Hauton⁶ ; who in the method which he published of making salt water sweet, very judiciously directs a certain earthy substance to be mixed with the distilled water, and gently to subside therein ; in order, as he says, “ to blunt the points of the volatile
“ spirits of the salt, and to sheath them,
“ and take away the force of their malign
“ sharpness”.

⁶ *Ph. Transf. ab.* vol. ii. pag. 277.

AND that the volatile acid of common salt may be easily separated from its fixed alkaline principle, appears from an experiment of the illustrious Mr. Boyle, who by a long and artificial digestion of this salt, so separated those its two principles; that when this digested salt was placed in a gentle sand heat without any addition, the spirit arose from it, pure, leaving the phlegm behind in the retort. Chemists have also taken notice, that common salt by being fused in a crucible acquires an alkaline quality, a large quantity of its acid spirit being dissipated in the operation; and that if afterwards it be exposed to the air, it easily runs *per deliquium*, much earth being left undissolved at the bottom of the vessel; and that, after it hath been several times fused, if some powder of charcoal be added to it, whilst in fusion, a sulphureous mass is produced, as if it was mixed with common brimstone⁷.

BUT a much milder heat than is required to fuse common salt, will separate its acid

⁷ See Hoffman's *Obs. Phys. Chem.* Lib. ii. Obs. xvi.

If credit may be given to Glauber, he could in a few hours so change sea salt, that it would acquire a fiery nature, and serve all the uses of pot ashes, and other lixivial salts.

spirit from its alkaline principle, as I was taught by the following experiments. I took about half a pound of pure crystals of bay salt from St. Ubes, and dissolved them in pure water ; several portions of this solution I mixed with syrup of violets, and with the tincture of flowers of Cyanus, and observed that the blue colour of the syrup and tincture was not changed either green or red, but rather heightened by the salt. The rest of the solution I boiled over the fire briskly in a clean iron pan, till most of the water was evaporated, and the salt remained in a solid form at the bottom of the pan, but still retained some moisture, and was not reduced to a perfect dryness. Some of this boiled salt being dissolved in pure water, and then mixed with syrup of violets or the tincture of Cyanus, instantly turned the colour of those liquors into a grass green. This experiment was often repeated ; and plainly shews, that the alkaline principle was predominant in this boiled salt, and that it had been deprived of a considerable portion of its acid spirit by the heat applied to it during its coction.

FROM all these experiments we may therefore conclude, that the volatile acid

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spirit,

spirit, may easily be separated from the fixed alkaline principle of common salt, by more ways than those practised by chemists in the distillation of those acid spirits; and that when salt water is exposed to the fire, very little or none of the spirit of salt arises while the heat applied is considerably less than that which is necessary to make rain water, or any other pure water boil; but if a greater heat be applied, so that the water with the salt dissolved in it be kept continually boiling till the evaporation be finished: then, during that part of the coction in which the water is only weakly impregnated with salt, no acid spirit, or very little arises⁸; but as soon as the water is so far evaporated, that what remains contains about a sixth part; or, if the water be viscid, like sea water, about a twentieth part of salt, it then acquires so great a heat in boiling as is sufficient to separate a considerable quantity of acid spirit from the salt, which spirit therefore flies off along with the watery vapours. And as the brine, during the eva-

⁸ These calculations are made upon a supposition, that the sea water used by Dr. Hales and Mr. Boyle in the above-mentioned experiments contained $\frac{1}{30}$ part of salt. For $30 - \frac{4}{5}$ of $30 = 6$. And $30 - \frac{2}{3}$ of $30 = 20$.

poration,

poration, continually becomes more fully saturated with salt, and grows continually more ponderous, it therefore continually acquires a more intense heat in boiling, which greater degree of heat separates a greater portion of acid spirit from the salt ; so that the spirit arises still in greater quantities, in proportion as the evaporation is carried on farther ; and the salt being thus deprived of part of its acid spirit, acquires an alkaline quality, and is also considerably diminished in quantity, when the coction is continued till all the water is evaporated.

THESE observations hold true in the common processes of preparing salt by coction. For all who are acquainted with the method of making white salt unanimously agree, that the salt contained in brine or other salt waters is considerably diminished in quantity, when those waters are made to boil violently towards the end of the process, after the salt hath begun to crystallize ; at which time the heat of the saturated brine, if kept boiling, is much more intense than that of boiling water. But the bittern which remains in the pan after the salt hath been extracted by so intense a heat, is found more in quantity, than when a moderate heat is

applied ; being increased by the alkaline part of common salt deprived of its acid spirit, by the violent coction. The salt made with this intense heat, is of a small loose irregular grain, and quickly grows moist in the air ; for which reason, the artists say, that it is not well cleared of the fresh. In order therefore, to obtain a larger quantity of salt, and of a better kind, they constantly slacken their fires, and boil very gently, as soon as they perceive the saline crystals begin to form in the brine. But they do not thus prevent the spirit of salt from exhaling in considerable quantities. For although the saturated brine only simmers or boils very gently, yet it then retains such a heat as is sufficient to drive off a considerable portion of this spirit ; and a considerable portion of it must also have exhaled before the time that the workmen slacken their fires, as appears from the foregoing experiments. So that white salt prepared after the common methods, must be deprived of a considerable portion of its acid spirit, by the violent coction used in its preparation.

L E M M A II.

Most kinds of white salt are rendered impure by the mixture of various heterogeneous substances.

IN the common processes of boiling salt from sea water, a large quantity of calcarious earth, called scratch, is observed to separate during the coction. Part of this earth closely adheres to the bottom and sides of the boiler, and there, forms a stony crust. Another part of it floats loose in the brine, in the form of a subtile powder, until it is cast to the corners of the boiler, where, being no longer agitated by the motion of the liquor, it subsides into small flat pans placed there to receive it. But all of it cannot after this rude method be separated from the brine; a considerable quantity of it still floats therein, until it mixes with the salt, and together with it is drawn out of the boiler.

MOST other kinds of salt water are greatly contaminated with the same calcarious earth; it abounds in the natural brines both of England and Germany, some of them containing as much of it as sea water does of salt;

and it is an advantage almost peculiar to the Droitwich brine to be entirely free from any mixture of this terrestrial matter. Salt therefore boiled from brine, as well as from sea water, is seldom without a mixture of this calcarious earth; since no greater care is used in separating it from natural brine than from sea water, in boiling them into salt.

THE same may also be affirmed of the salt refined from a solution of the English fossil salt; in boiling of which, this earth is observed to float about, and is collected into scratch pans, as from other salt waters.

BESIDES this calcarious substance, most kinds of brine hold a ferruginous earth or ochre, which is sometimes mixed with the salt, and renders it of a dirty colour. At several of the Cheshire salt works, where they use a very strong brine, the first draught of salt, or clearing of the pan as they call it, is rendered so impure by this, and other heterogeneous mixtures, that they throw it away as useless.

THE earthy substances mixed with salt, may easily be discovered by dissolving it in pure water, and suffering the solution to remain quiet, till all the gross substances which were mixed with the salt have subsided to
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the bottom of the vessel. Most kinds of boiled salt that I have had opportunities of examining, as sea salt, Cheshire brine salt, rock salt refined in Cheshire and Ireland, when thus dissolved in pure water, constantly let fall a white earthy sediment in considerable quantities ; and in most of their solutions I have likewise observed large scales of scratch which had been disunited from the sides of the salt pan. On most of these solutions there also arose a frothy scum, which was much more copious, and of a more dusky colour on the solutions of those salts which were mixed with butter and other additions, than of those which had been prepared without them. I have also observed coal dust, sand, and other gross impurities frequently mixed with several kinds of white salt.

BUT besides the earthy and other gross substances found mixed with white salt ; it is commonly rendered still more impure by a mixture of salts of a different nature. For in the process of boiling salt from sea water, it was observed that a considerable quantity of a ponderous, sharp, unctuous, bitter liquor remained in the pan, after all the salt was extracted ; and that a considerable quantity

tity of the same bitter liquor also drained from the salt after it was drawn out of the pan. Now, although those who boil sea salt suffer the bitter liquor to drain from it for several days; yet it cannot be imagined that all the bitterness is, after that manner, separated from the sea salt; a considerable quantity of it doth undoubtedly still adhere to the salt in a liquid form; and a large quantity of the bitter purging salt is often reduced into crystals along with the common salt; and sometimes may be discovered in it even by the taste. And those who know how difficult a matter it is to refine nitre, and other salts, and separate them one from another, and render them pure by crystallization, will readily conclude, that it is almost impossible to separate the common salt entirely from the other salts contained in sea water, after the tumultuary manner in which the process of boiling sea salt is usually performed.

MOREOVER most kinds of brine salt are probably also rendered impure by a mixture of the bitter purging salt, and other calcareous salts. The bitter purging salt is observed greatly to abound in the bowels of the earth, and to impregnate, not only the ocean,

ocean, but also several lakes, as the lake of Sodom or Dead Sea, whose waters are thereby rendered extremely bitter. It is probably this salt that gives most of the springs in Arabia, and some other parts of Asia their bitter taste, and renders them unpotable. And in England, we find a vast number of springs impregnated therewith, and together with it almost constantly to hold a muriatic salt; so that this bitter salt and common salt are usually found together dissolved in the same water; as in the brine of Cheshire, if in this particular, credit may be given to Doctor Leigh. Rock salt likewise often holds a mixture of this bitter salt; it is discovered by the taste in the fossil salt of Armenia, and renders the salt of the mountain Had-deffa so bitter, that it is unfit for domestic uses until it hath undergone an accidental purification¹. And that most of the brine springs in Germany hold a kind of bittern, we are assured by Dr. Fred. Hoffman; although from his experiments their bittern seems to contain much more of the sharp pungent muriatic calcarious salt, than of the bitter purging salt

¹ See note from the Rev. Dr. Shaw in the introduction.

before described. It can therefore scarce be imagined, that the English brine salts are wholly free from a mixture of these calcarious salts of the bitter; especially when it is considered that the brine salt makers are not accustomed to throw away any of their liquor; but constantly mix the leach brine, which remains in the pan, or drains from the salt, with the brine fresh drawn into the pan, and so boil them up together into salt.

As to the refined rock salt made in Cheshire, it not only contains all the heterogeneous salts of the native fossil salt; but also, all the bitter salts of the brine or sea water, with which the fossil salt is refined. For neither do the refiners usually throw away any of their leach brine; but mix it in the pan with their fresh solution, and therewith reduce it into salt, hardening up all together in their hot houses.

BESIDES these calcarious salts, most kinds of boiled salt are also mixed with a fixed mineral alkali. This alkaline salt may easily be discovered in the marine bitter by syrup of violets, which it instantly turns green; and in the same manner it may probably be discovered in most kinds of leach brine, by those who have opportunities of trying them.

them. I have frequently mixed various kinds of white salt, as sea salt, brine salt, and refined rock salt, with about an equal weight of pure water ; and after the water had dissolved near as much of the salt as it could keep suspended, have poured off the clear solution ; and, when the salt had not before been long exposed to the air, almost constantly observed that its clear solution prepared in the foregoing manner, being mixed with the tincture of flowers of Cyanus, turned it from a fine blue, to a green colour ; which change of colour plainly discovered that the salt contained some mixture of a mineral alkali. Some of these solutions would instantly change the colour of the tincture, but others not till after twelve, or twenty-four hours, and then only to a pale green. But the solution of fine Portugal salt made after the same manner, had no such effect upon the tincture, but rather heightened its blue colour ; and this colour it retained much longer when mixed with the last mentioned solution, than when mixed with pure water in the same proportion. In making these experiments care should be taken that the solutions be perfectly clear, and free from any mixture of calcarious earth ;

earth ; otherwise the change of colour may proceed from the alkaline earth, and not from any perfect alkaline salt. From the experiments made by boiling pure bay salt as before related², it appears that the alkaline salt found mixed with white salt, may sometimes be the alkaline principle of common salt deprived of its acid spirit by violent coction. At other times, it may have existed in the form of an alcali in the salt water before its coction. In both cases its nature and effects will be nearly the same.

BESIDES the various kinds of salts and earthy substances before taken notice of ; we are assured by Mr. Boyle, that common salt sometimes participates of combustible sulphur. That most kinds of natural brine contain a sulphureous principle, is very certain ; and this principle may sometimes be of so fixed a nature, or so entangled with the salt, that it cannot easily separate from it, and fly off in boiling. Altho' it is probable that most of the sulphureous substance mixed with boiled salt may rather be artificial than natural ; and may proceed from the butter and other unctuous substances used by many salt boilers ; which incorpo-

² Under the foregoing lemma pag. 227.

rating with the salt, especially when it is burnt and rendered alkaline by violent heat, may with it form a kind of liver of sulphur, as in the experiments before related³. The like may sometimes happen when fat blood is used to clarify the brine.

Also flower, rosin, and many other additions which the operators use, seem scarce to have any good effect, but load the salt with a still greater variety of impurities.

L E M M A III.

White salt, by the violent coction commonly used in its preparation, is rendered less fit for preserving flesh, fish, and other provisions, than it would be if prepared with a more gentle heat.

It is well known to chemists, that common salt, by means of fire may easily be resolved into two principles; and of them again may be composed. These principles are a fixed alcali, and a volatile penetrating acid spirit. To the last of these principles is owing the power and efficacy which salt hath upon animal substances; whereby it gently contracts and hardens their solid parts,

³ See page 233.

restrains the intestine motions of their fluids, and so preserves them from corruption. That the acid spirit of salt possesses these qualities in a most extraordinary degree hath long been known to anatomists; amongst whom it hath been a secret to mix a few drops of it with the fermented spirits in which they preserve their injections, and other curious preparations.

THE Rev. Dr. Hales found that this acid spirit would prevent common water from putrifying. He also experienced that beef might be preserved sweet a considerable time in water, by mixing with it this acid in the small proportion of three drops to an ounce of the water.

⁴ “ INTO two ounces of the last portion
 “ of the distillation to driness of sea water,
 “ the same gentleman put a small piece of
 “ fresh beef: and put beef also into the like
 “ quantities of well-cured sea water, (which
 “ had no spirit of salt mixed with it) and
 “ also of rain water. In seven days the two
 “ last were become fetid and putrid, and
 “ the water thick and cloudy; whereas,
 “ the beef in the very bad sea water (im-
 “ pregnated with spirit of salt) did not pu-

⁴ Dr. Hales *Philosophical experiments*, pag. 15, 16.

“ trify,

“ trify, nor was the water turbid, but
“ clear as at first, though kept seven or
“ eight weeks with the flesh in it. And it
“ was observable, that the restraining qua-
“ lity of the bad distilled sea water was so
“ great, that it contracted the fibres and
“ blood vessels of the beef, so that no blood
“ could issue out of them; as it did from
“ the first day from the beef in the other
“ glasses, which had good wholesome dis-
“ tilled sea water, or rain water in them.”

THESE experiments sufficiently shew the extraordinary efficacy of spirit of salt in preserving animal bodies from corruption. But this spirit is of too sharp and corrosive a nature, and too noxious to the human body to be used as a condiment for food, unless its too great acrimony be allayed by the alkaline principle of common salt. For this, as well as all other acids, strongly coagulates the blood of animals, when mixed therewith: whereas, neutral salts have no such effect; and several of them, when dissolved in water, may even be injected into the veins of animals, without doing them any great prejudice. Common salt, most especially, is found friendly to animal nature; its acid spirit being so tempered by its alkaline prin-
R ciple,

ciple, that, when mixed with blood, it is thereby prevented from growing too thin and putrid, to which it hath a natural tendency; and the texture of the blood is thereby also preserved so intire, that for years it preserves its gummy balsamic quality. This hath been experienced in beef pickle; the animal juices in which, after it had been kept for years, have coagulated by heat, as if they had been blood fresh drawn from a vein; and this pickle hath often been used by the salt boilers to clarify sea water instead of whites of eggs. Common salt, therefore, as it is of a middle nature, between acids and alcalics, hath neither the bad effects of the one, nor of the other, upon the juices of animals. For, when mixed with blood, it does not coagulate it like acids; neither does it thin the blood and destroy its glutinous texture, and reduce it to a tabid corrupted state, as all alcalies, whether fixed or volatile are found to do.

THE alkaline principle therefore, of common salt, when separated from its acid spirit, is so far from having any efficacy as a condiment, that on the contrary, it corrodes and dissolves animal substances, and promotes their putrefaction. All alcalies are
found

found to have these effects, especially the more fixed kinds, as they strongly attract unctuous and aqueous substances, and by that means quickly penetrate the flesh of animals; insinuating themselves between its fibres, and dissolving their cohesion; when mixed with the juices of animals, they also act violently upon the neutral salts which they contain, uniting to the acid principle of those salts, and separating it from the volatile alkali to which it before was joined, and thus exciting intestine motions in those juices, and promoting their corruption. Surgeons, therefore, know no better caustic for corroding the flesh of living bodies, than that which is composed of soap and quicklime. And those who are employed in dressing leather, find nothing so proper to tender skins, and reduce their external parts to a semi-putrid state, as lime mixed with water; in which they steep their skins in order the more readily to separate the hair from them. These observations sufficiently shew the effects of lixivial salts and quicklime upon animal substances, and how by them the solid parts of animals are corroded, and their fluids rendered sharp and thin, and the

whole quickly reduced to a state of corruption.

AND that the alkaline principle of common salt hath a very great affinity to the lixivial salt of vegetables is plain and evident, since it is of a fixed nature soluble in water, and hath the same effects with those lixivial salts upon fyrup of violets, and other blue tinctures of vegetables ; like them it greedily imbibes the aerial moisture, and with it runs *per deliquium* ; and like them also it readily unites to the phlogistic principle of charcoal, and with it forms a sulphureous mass, as hath before been observed. The lixivial salt of vegetables will even supply the place of this alkaline principle ; and when mixed with the acid spirit of salt, is with it converted into a neutral salt, which does not appear in any respect different from common salt⁴.

⁴ Except it should be found that the solution of this factitious common salt, made in pure rain water, will not grow turbid when mixed with the solution of salt of tartar. In which particular it may probably differ from all kinds of marine salt, whether bay salt or boiled salt, that I have had opportunities of examining ; whose clear solutions constantly grew white when mixed with the said solution of salt of tartar, contrary to what is asserted by Mons. du Clos in the *Mem. de l'Acad. Royale des Sciences*. And these solutions, thus mixed together,

COMMON salt therefore owes its property of preserving animal substances solely to its acid spirit; and in proportion as it hath more or less of this acid, it is more or less strong; that is to say, it is more or less sharp and pungent to the taste, and hath a greater or less power of preserving animal bodies from putrefaction. For it appears, that salt, deprived of a considerable part of its acid spirit, may yet retain the form of salt, although it cannot then be esteemed a perfect salt, but rather a kind of decrepitated salt, in which the alkaline principle is predominant. Such salt is commonly of a small, loose, irregular grain, and is disposed to grow moist in the open air, and is said constantly deposited a very light earthy sediment, and in several of them, part of this earthy matter was also suspended like a cloud; and more of the solution of tartar being added to the mixture after it became clear, it did not again grow white and turbid; which shews that common salt only contains a small portion of this white earth which may thus be precipitated from it. I also observed a small portion of a very alkaline earth to settle in the solution of the white salt prepared by violent coction from bay salt, after the manner before related. Salt after fusion, being suffered to run *per deliquium*, hath also been observed to deposite an earthy matter, as before related. All which observations seem to prove, that the alkaline principle of common salt is not all of it a perfect fixed alkaline salt; but that some part of it is an alkaline earth approaching to the nature of quicklime.

to be weak, because of a flat taste, and improper for curing provisions for exportation into hot countries.

AND such, in a greater or less degree, are most kinds of white salt now made, being deprived of a considerable portion of their acid spirit by the violent coction used in their preparation, as hath before been demonstrated. And this is confirmed by the practice of the Cheshire salt boilers ; who, when they formerly boiled their salt in a very hasty manner, found it unfit for keeping, and only made it for present sale. Whereas, now by using a much slower heat, they prepare salt much fitter for preserving provisions; and by applying more gentle fires than ordinary, they prepare their shivery salt ; which is the strongest salt, and of the firmest and largest grain of any that they make. So that in proportion as the heat made use of in boiling white salt is greater or less, a greater or less quantity of the acid spirit is dissipated ; the weakest salt being prepared by the most violent heat.

THE British salt boilers, therefore, though they have made several improvements in their art, have not yet brought it to the utmost perfection ; for the heat which they
still

still use is so intense, that by it a considerable portion of the acid spirit of salt is wasted; and the salt which they prepare is always less sharp and pungent than bay salt, which is extracted by a more gentle heat; and for this, and other reasons, hereafter to be given, is less proper than bay salt for curing provisions. The Dutch, therefore, when they would make a kind of white salt fit for preserving provisions, very prudently take care to waste the water, in which the salt is dissolved, by a very slow and gentle heat, not much greater than the solar heat in the warmest climates, and by this means they obtain a strong and vigorous salt, fully saturated with its acid spirit, and extremely proper for the uses for which it is intended. For by such a heat none of the spirit of salt is dissipated, as appears from the experiments of Mr. Boyle and others, before related.

L E M M A IV.

The heterogeneous substances which are commonly mixed with white salt, render it less proper for preserving provisions, than it would be if separated from them.

THE heterogeneous substances found mixed with most kinds of white salt are chiefly

the calcarious earth called scratch, the bitter purging salt, and the muriatic calcarious, and alkaline salts before described.

THE calcarious earth which commonly abounds in boiled salt (and particularly in sea salt, and most kinds of brine salt used in England) can no ways be proper for preserving meat, approaching too near to the nature of lixivial salts and quicklime¹. A substance of so alkaline a nature as scratch, can therefore in no wise contribute to preserve the flesh of animals; but, on the contrary, must rather corrode and destroy it, and promote its putrefaction.

AND hence it probably is, that the Droitwich salt, which is perfectly free from scratch, hath, by impartial judges², been esteemed a stronger salt, and fitter for preserving provisions, than any kind of brine salt, prepared after the same way with it, in other parts of England.

As to the bitter salt, and the muriatic calcarious salt of bittern, of all neutral salts they are soluble in the least quantity of water, and most greedily imbibe the aerial moisture, and most readily unite to unctuous

¹ See part ii. chap. ii. § 3.

² As by Dr. Lister and others.

substances. So that when mixed with common salt, they dispose it to relent and grow soft in the open air ; and when applied with it to the flesh of animals, they prey upon the fat, and with it unite into a kind of soap ; they also do not suffer the salt to fix and harden in the meat, but dispose it to dissolve with the juices, and to run out with them in pickle ; and the meat, being thus deprived of its fat and juices, is left open and spongy, so that the air easily penetrates and corrupts it.

THE fixed alkaline salts, so frequently mixed with white salt, will have the same effects upon the flesh of animals with the bitter and calcarious salts before related ; moreover they will corrode the solid parts of animals, and promote intestine motions in their fluids, and render them thin and acrimonious, as hath before been explained. And to these alkaline salts seem chiefly owing the disagreeable red colour, and tabid slime, frequently observed in beef, that hath been pickled with weak and impure salt.

THOSE therefore who prepare brine salt in England, seem guilty of a capital error, when they mix the leach brine which drains from the salt, or remains in the pan after
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the process is finished, with the brine fresh drawn from their cistern, and boil them up together into salt. For by this means they render their salt impure, and less fit for domestic uses; as it hath mixed with it a much greater proportion of alkaline, bitter, and calcarious salts, than it would have if the leach brine was either thrown away, or applied to other uses.

THEY also commit a yet greater mistake, who, when they refine rock salt with sea water, do not throw away their leach brine, or bittern, but mix it in the pan with their solution, and harden up all together into salt. And it seems entirely owing to this very faulty method, that the Cheshire fossil salt refined with sea water, is of a worse quality than their brine salt. For as their brine is only a solution of rock salt made in the bowels of the earth, often in very impure water, there could be no reason why the brine salt should be better than the refined rock salt, if both were boiled after the same manner; the rock salt having first been dissolved, not in sea water or impure brine, but in purer rain or river water.

SEA salt therefore prepared by the heat of the sun, as it is more free from scratch and the
salts

salts of the bittern, than most kinds of white salt, is more proper for preserving flesh and other kinds of provisions. For the marine bay salt is not extracted in a hasty and tumultuary way, but by a slow and gentle heat; so that when a certain portion of the water hath exhaled, the calcarious earth separates from it, and subsides in the brine ponds, being deposited before the brine enters the salt pits³. The brine, thus freed from its calcarious earth is, received into the salt pits, where the saline particles concrete together, and after they have united into large crystals, are drawn out pretty free from the salts of the bittern, which remain dissolved in their watery vehicle. For chemists have observed, that when different kinds of salts are left to crystallize in a saline lixivium, those constantly shoot first which require the largest quantity of water to dissolve them; and very little of the more soluble salts will form into crystals while there remains a sufficient quantity of water to keep them dissolved. The bitter brine which remains in the salt pits, is frequently drained out of them; And if any of the salts of the bittern happened to be mixed with the bay salt, they are often washed out

³ See the foregoing description of the French saltmarsh, Part i. Chap. iv.

of it by rains, while it lies in heaps exposed to the air.

THUS a strong muriatic salt is obtained from sea water, turgid with its acid spirit, sufficiently freed from calcarious earth and bittern, and very proper for all culinary uses. For although it hath often a considerable quantity of slimy mud, clay, and sand mixed with it, which give it a dirty colour, yet these impurities do not penetrate the flesh of animals, but only adhere on its outside in a dirty crust, which may easily be washed off; so that they indeed make the meat more unsightly, but have no other bad effects upon it, and do not render the salt with which they are mixed unfit for preserving it.

As to the strong Dutch refined salt, it is certainly of all kinds of salt now made, the most pure, and in that respect the most proper for preserving provisions. For it retains scarce any calcarious earth, or salts of the bittern; it is also free from mud and other impurities with which bay salt is contaminated; and if it acquires any alkaline quality by boiling, that is corrected by a mild acid which is added to the brine. It is not, therefore, at all to be wondered at, that the Dutch white herrings cured with this salt, look much more
fair

fair and beautiful, and keep longer, and consequently sell for a better price, than those that are preserved with other kinds of salt.

P R O P. I.

From sea water, fossil salt, or natural brine, to prepare a kind of white salt proper for curing fish, flesh, and other provisions.

By the foregoing facts and arguments it seems to have been sufficiently demonstrated, that the common kinds of boiled salt are in some things deficient, in others redundant; that they want a considerable portion of their volatil acid, without which the other principles of salt have no efficacy as a condiment, but are like a dead body deprived of its quickening spirit; and that they abound with many impurities, as earths, sulphurous bodies, heterogeneous salts, hurtful additions of various kinds, ashes, soot, coal, &c. which, instead of preserving, defile and corrupt the flesh of animals to which they are applied.

MOREOVER, it seems to have been fully proved that those kinds of salt which are fully saturated with their acid spirit, and sufficiently depurated from hetero-
geneal

geneal mixtures, are extremely fit and proper for preserving fish, flesh, and other kinds of provision.

AND forasmuch as all kinds of common salt, when pure and perfect, are found to be of the same nature and to agree in the same qualities ; from these premises may therefore be drawn the following conclusion : That any kind of common salt which is perfectly free from all heterogeneous mixtures, and hath not been deprived of any part of its acid spirit, is extremely fit and proper for curing all sorts of provisions.

THE requisites in the foregoing problem will therefore be fully satisfied, if from sea water, fossil salt, or natural brine, white salt be prepared free from all impurities, and no ways weakened by a dissipation of its acid spirit.

THIS may be fully effected at two operations. In the first of which, from the salt water must be prepared a good kind of white salt, more fully impregnated with its acid spirit, than salt boiled after any of the common methods. And in the second operation, the white salt thus prepared, must be refined from the impurities with which it is still mixed, and reduced to a purer and stronger

stronger kind of salt ; after nearly the same manner that bay salt is now refined in Holland.

IN the first process, if sea water be used, the following method is recommended ; by which a marine salt may be prepared better in quality, and also at a less expence, than by any of the methods of boiling sea salt that are now in practice.

FIRST, let the sea water be heightened into a strong brine by the sun, after the method practised in Hampshire, and other parts of England ; or (which will be a better and less expensive method) in a salt marsh constructed after the French manner, from which large quantities of bay salt may be drawn at proper seasons ; and when the weather is less favourable, brine may be collected into large cisterns there to remain until it is drawn out to be boiled into salt.

FOR this purpose a saltern must be erected adjoining to the salt marsh, and in it must be placed a large boiler or salt pan made of iron. The bottom of the pan may be of a square figure, forty feet on each side, and its depth may be eighteen inches¹. Or the

¹ If the pan is made of a square figure, the scratch may conveniently be collected at its corners into flat
pan

pan may be made of a cylindrical form, forty feet in diameter, and eighteen inches deep; which is the most common size and figure of the pans used in Holland². The furnace over which the pan is erected may have four mouths, made on the opposite sides, at equal distances, for the conveniency of receiving fuel. The fire may be made on a hearth; and within the furnace must be

lead pans. But if of a cylindrical form, the scratch may be raked from its bottom, as at the Lemington works. And if any salt be raked up with the scratch, it need not be lost, but may be dissolved from among it by water. Or if a considerable quantity of scratch remains mixed with the salt, it will with other gross impurities subside in the brine, when the salt is again dissolved in water, as directed in the second process.

At one corner or side of the pan may be fixed a pipe with a cock, through which the bittern may be drawn out, when occasion requires, and thither there may be a gentle fall from all other parts of the bottom. It is true indeed that in the common processes of making salt, the pans are so shaken by the violent boiling that they do not long retain the same position, by which motion of the pans their joints are loosened, and their bottoms often cracked and bulged; so that by such accidents a pipe might soon be rendered useless. But these accidents might probably be prevented by fastening the pan down in its situation with strong bars of iron, firmly fixed in the earth, and hooked close to the corners and sides of the pan.

² It may probably require a large salt marsh or even several salt marshes, in order to keep a pan of this size constantly at work.

erected proper pillars of brick or mid-feathers ; and, if occasion requires, strong posts, and cross bars of iron, to support the bottom of the salt pan. There must also be four funnels for conveying away the smoke, placed at equal distances between the mouths of the furnace. If the pan be square, the funnels may be carried up at its four corners, and the mouths may be under the middle of its four sides. The mouths must all have doors fitted to them very close ; and the funnels for conveying away the smoke, must have registers ; all which may be opened or shut, as occasion requires, for the more convenient regulating of the fire.

THINGS being thus prepared, let the salt pan be filled with strong brine, drawn from the cistern, and well cleared from its muddy sediment. Then, kindle the fire (pit coal will serve very well for this use, and will, in all parts of Great Britain, be much cheaper than cinders and the most parts, than any other kind of fuel) and mix a sufficient quantity of whites of eggs with the brine to clarify it from its viscous matter, and other light impurities. Let the brine at first boil gently, and when the scum hath all arisen, take it off

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after

after the manner before directed³. As soon as the brine is skimmed, abate the fire, and only let a moderate heat be applied, sufficient to keep the brine of a scalding heat, which may be a heat of about two hundred degrees in Farenheight's thermometer. When the salt begins to grain, rake out the scum, which will then be fallen to the bottom of the pan. When the brine is thus fully depurated, in order to correct its alkaline quality, a proper quantity of four whey may be added to it, which can do no harm, and hath long been used by the Dutch with success⁴. After the whey hath been added, the brine must be kept of a scalding heat all the time that the salt is graining or forming into crystals. And when most of the salt is crystallized, and lies in the pan almost dry on its surface, the fire must be damped by shutting the doors of the furnace, and the registers; and the salt must be drawn from the liquor to the sides of the pan, and put into drabs, or other proper vessels, till all the

³ Part ii. Chap. ii. Sect. 1.

⁴ The alkaline salt will by this acid whey be converted into a neutral salt, resembling the Tartarus regeneratus, which will remain dissolved in the bittern.

bitter liquor is drained from it ; and then it will be fit to be used in the second process of refining.

THE salt pan, after every second or third time that this process is finished, must be emptied of the bittern ; and at proper times must also be cleansed from the stone scratch adhering to it.

THUS may be prepared a good kind of sea salt, stronger, and of a much firmer and larger grain than any kind of common white salt made by the methods now in use. And after this manner may also be prepared a salt for the table, better in quality, and at a less expence than by the common methods. Only as such salt is required of a fine grain, it may be granulated with quicker fires than here directed, and may be drawn out of the pan before it hath lain long enough to form into large crystals ; so that it may be taken out at five or six draughts during the process. The second and third draughts will be the best salt, being the most free from scratch, and the salts of the bittern.

AFTER the same manner a good kind of white salt may be extracted from natural brine ; and likewise from a solution of rock salt in weak brine or sea water.

BUT if instead of strong brine, salt water as drawn from the sea be used in this process, then it may be proper to have a salt pan of twice the capacity of the pan above described; so that it may be a yard in depth⁵, and forty feet in diameter. The sea water received into this pan, after it hath been clarified with whites of eggs, may be made to boil very violently⁶, until one half,

⁵ We are told of pans of this depth being used at some foreign salt works, as at Inn'thall and Roche; and such are used in England at the copperas works. An addition made to the depth of the pan by heightening the sides with strong sheets of lead; and also covering with them a rim of timber fixed round the top, may make the pan of double its former capacity, at a small increase of cost. What effect such a weight of water may have upon the bottom of the pan, and whether it will require greater fires to boil it, or whether the evaporation will be proportionably quicker in such deep pans than in shallower, are questions which may best be determined by experiments. Certain it is, that with such pans there will be much less trouble in filling them up, and clarifying the brine; and also much less danger of burning the salt, and wasting its spirit, than in shallower pans.

⁶ The violent boiling, here directed, will greatly shorten the process, and will not much weaken or waste the salt by dissipating its acid spirit. For from Dr. Hale's experiments, it appears that scarce any of this spirit arises from boiling sea water until more than one third of the water is evaporated. And when the sea water hath been clarified from its viscous matter, it is probable, from the same gentleman's experiments, that little

or eighteen inches depth of it, be evaporated ; and then the pan may be filled up with sea water a second time, which must be clarified, and boiled down a foot in depth ; and then filled up a third time, and clarified as before. After which the liquor must be evaporated to a strong brine, taking care to lessen the fire as the brine increases in strength, and when it becomes so strong as to contain about a fifth part of salt, then only to use a scalding heat ; taking out the powder scratch when the salt begins to fall, correcting the alkaline quality of the brine with four whey, and graining the salt with a scalding heat, as before directed.

THE white salt being prepared according to the methods above proposed : Then, in the second process of refining, take a sufficient quantity of this white salt, put it into a large cistern made of wood, or bricks and clay ; add to it as much pure river water

of this spirit will arise before half of the water is evaporated ; as directed in this process. But if the violent coction be continued till the salt begins to grain, and the brine afterwards be suffered to simmer during the whole process, according to the common practice ; the salt will be greatly diminished in quantity, and weakened in strength by the dissipation of its acid spirit.

as will be sufficient to reduce it to a strong brine, almost fully saturated with salt; when the salt is dissolved, let the brine stand quiet, and if any scum arises, take it off: A large sediment will fall to the bottom of the cistern, which, when all is settled, the clear brine is fit for use.

THE salt pan most proper for working this brine is the same that is proposed for preparing white salt from brine in the first process. The pan will be more proper for this use, when its inside is covered with a crust of scratch, than immediately after the said crust hath been picked off it.

THE pan being carefully cleansed from bittern, the clear solution of white salt, prepared as before directed, must be drawn into it, out of the cistern, by troughs, cranes, or pumps; care being taken that all the calcareous earth, and other impurities of the white salt, settled to the bottom of the cistern, do there remain undisturbed. The fire must then be kindled in the furnace (pit coal will serve very well for this use) by which the watery part of the brine must be slowly evaporated; care being taken that the heat used be so mild and gentle that none of the saline spirit be separated by it. The heat of the
brine

brine during the whole process from first to last, must therefore be equal and regular, and considerably less than the heat of boiling water ; perhaps a heat of one hundred and sixty, or one hundred and eighty degrees in Farenheight's thermometer may be the most proper. A little experience will shew the greatest heat that salt can endure without any dissipation of its acid spirit ; and that is the heat here proposed to be used. The expert artist, by means of the registers in the chimneys, and the doors of the furnaces, may so regulate the fire, as to keep the brine constantly heated to a certain degree of the thermometer, if such exactness should be required.

WHEN the evaporation is so far advanced that little saline crystals begin to appear on the surface of the brine, then may be added thereto a sufficient quantity of the acid muriatic spirit, so that neither the acid nor the alkaline principle of the salt may remain predominant⁷. Which being done, the eva-

⁷ The quantity of acid spirit here proposed to be added may be exactly determined by proper assays ; for if it be found by experiments that a gallon of the brine requires one, two, or three drops of the spirit to saturate it ; from thence may be known the quantity required to saturate all the brine contained in the pan.

poration must be continued until so much salt is formed in the pan that its surface is almost dry. The doors of the furnace and registers must then be closed, and the fire smothered out; and the salt, which will be found in large clear crystals, must be raked to the sides of the pan, and, when it hath drained there a little time, must be taken out and put into drabs or other proper vessels to drain further from the superfluous brine, and then will be fit for sale.

THE strong brine which remains in the pan after the refined salt is drawn out, and the brine that drains from it, ought not to be mixed with the solution intended to be made into refined salt; but will serve to mix with the brine to be boiled up in the first process into common white salt.

THE salt refined after the foregoing process will be exceeding strong and pure, and will have all the qualities required in such salt as is most proper for preserving fish, flesh, and other provisions.

FOR first this salt will be extremely well depurated from all earthy alkaline substances, and from all the salts of the bittern, and all other mixtures of a different nature from it. So that in purity it will greatly exceed bay salt,

salt, and even the Dutch refined salt, which they do not refine with pure river water, but with sea water, which abounds with calcareous earth, and bitter salts, as hath before been demonstrated.

SECONDLY, the salt thus prepared will be extremely strong, and fully satiated with its acid spirit. For the white salt proposed to be thus refined, is a stronger kind than any now commonly made. But should a much weaker kind be used, which had been deprived of a considerable quantity of its acid spirit, even from this weak salt a strong pure salt may be prepared after the manner proposed in the second process. For the saline particles deprived of their acid, as they are not a perfect muriatic salt, cannot therefore form into cubic crystals, but will either subside in the brine, in a white powder, or else, after the process is finished, will remain in the mother brine or bittern in the form of an alkaline salt; so that only the strong pure crystals of salt will be reduced into a solid form in the second process; but in the second process, here recommended, care is taken again to restore to those alkaline particles, the acid spirit of which they had before been deprived, and with it to convert them

them into a perfect muriatic salt. And the heat wherewith it is proposed to evaporate the water from the brine, being mild and well regulated, none of the acid spirit will again be wasted. The salt therefore refined according to the method here proposed, may well be esteemed a purer and stronger salt than that refined by the Hollanders, and at least equally excellent for preserving provisions. So that it will fully answer all the requisites in the foregoing problem.

As to those additions which many recommend in order to make the salt grain or crystallize better, and to render it of a firmer and harder texture, they seem in this process entirely superfluous, and would prove prejudicial rather than serviceable, by rendering the salt impure. For when the watery vapours exhale from the brine, by a mild and gentle heat, the salt naturally forms into large hard crystals without any addition, as may be observed in the preparation of bay salt.

IN the above process for refining white salt, the most exact methods are described; although in practice such great accuracy may probably not be required: So that instead of the strong white salt prepared according
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to the first process, a weaker kind, boiled with more violent fires, may probably be substituted without any damage; and instead of pure river water proposed in the second process for dissolving the salt, sea water may be substituted, agreeably to the practice of the Dutch, and then a considerable part of the expence will be saved. There are even some kinds of natural brine so free from scratch, bitter salts, and other impurities, that, after they are depurated from their sediment, and properly clarified, may probably, by the method proposed in the second process, be reduced into a pure strong salt, fit to be used as a condiment without undergoing the previous operation of boiling into white salt; such, probably, may be the excellent brine of Droitwich.

AND although the brine of Cheshire, and also the rock salt of that county, contain much scratch and other impurities, insomuch that the Dutch have found by experience, that the latter cannot, by their method, be refined into so strong and pure a salt, as that which they prepare from marine bay salt; yet there is great reason to believe, that, if the muriatic spirit before recommended be
rightly

rightly applied and other proper means be used, a strong and pure white salt may be prepared, at one process, not only from English rock salt, and most kinds of English brine, but also from sea water, which will be very fit for curing provisions, in all the different ways, and for all uses. For so great is the efficacy of this spirit, that by a proper mixture thereof, even common white salt may, in cases of necessity, be made to serve for curing beef for long voyages; as I have reason to conclude from my own experiments, as well as from others, with which I have been made acquainted.

P R O P. II.

In several parts of Great Britain, white salt might be refined by the foregoing method, at a small expence, and in any quantity wanted.

It is a happiness to Great Britain to be surrounded with seas, which, besides other advantages drawn from them, may be made to yield an inexhaustible store of salt. This island likewise abounds in rock salt, and natural brine; from all which refined salt may
be

be prepared in any quantities that can possibly be wanted, either for home consumption, or for exportation abroad.

MOREOVER, it is a blessing peculiar to this island, to have vast mines of fossil coal in many places, nigh the sea, and nigh salt springs and mines of rock salt; with which coal, salt might be refined much cheaper here than in most other countries.

IN many parts of Great Britain, as at Shields, pit-coals are so cheap, that salt boiled with them from sea water, can be afforded at so small a price as eight pence per bushel; and might, no doubt, be afforded at such places, for half the money, if, instead of boiling sea water into salt, they used the same water first heightened into brine by the sun and air, after the method here proposed; and if, instead of pans holding about 1800 gallons, they used pans like those of the Dutch, holding nigh ten times that quantity.

THE salt boilers at Lemington who heighten sea water into brine (by a method not the most commodious) use chiefly Newcastle coals in boiling their salt, and pay five or six times the price for them that is paid at Newcastle or Shields. But in making a
certain

certain quantity of falt, they only evaporate one gallon of water by fire, for eight or ten gallons evaporated by the falt boilers at Shields ; and with a pan of the same magnitude, and the same quantity of coals used at Shields, can make at least five or six times the quantity of falt that is made at the latter place ; by which means they are able to sell their falt at the London market, even cheaper than the falt boilers of Shields. From whence appears the great profit of heightening the sea water into brine, by the force of the sun and air.

THE great advantage of using large pans like those of the Dutch will also appear, by considering, that a large furnace will require less fuel in proportion to its magnitude to heat it to a certain degree, than is required in a smaller one ; and that two labourers, who are now employed in working two falt pans of the common size used at Shields, which hold each about 1800 gallons, will, with greater ease, work a large pan, of the size above proposed, holding about ten times that quantity; so that the price of labour and fuel (which are the articles of the greatest expence) will be much less in the
larger

larger work than in the smaller, in proportion to the quantity of salt made in each.

THE Dutch, in refining salt for the table, work out one of their large pans of brine every twenty-four hours; and if, from each gallon (wine measure) of the brine used, two pounds and an half of salt be extracted; then, in a pan whose bottom is forty feet square, and depth eighteen inches, they usually make 801 bushels of table salt every twenty-four hours¹. And the same quantity of salt might be made from brine of equal strength, in an equal time, whether the brine be a solution of coarse bay salt, as used by the Dutch, or sea water heightened by the sun, after the manner before proposed. But, as in the first process before described, it is proposed to evaporate the brine with a very gentle heat, in order that the salt may be very strong; we shall therefore suppose only six inches depth of brine to be evaporated every twenty-four hours, and then the whole process will take up three days;

¹ Supposing the pan to be filled quite to the brim; but if the pan should not be quite filled, they may notwithstanding make this quantity of salt every twenty-four hours, by using a stronger brine than here supposed.

and

and such gentle fires will be applied, that probably not much more fuel will be consumed in those three days, than is consumed in the same time, in boiling sea water with violent fires in the common Newcastle salt pans, which hold about 1800 gallons. Although in the large pan 801 bushels of strong salt will be made in three days; and only about 60 bushels of a weaker salt in the small pan, by the method now in use, as I have been assured by very good judges.

BUT if, in working the large pan, according to the method here proposed, it should be granted, that even twice as many coals were consumed as would work a Newcastle salt pan of the ordinary size, with violent fires, which is certainly a very large allowance; then, as many coals would be consumed in three days, in working the large pan, as would make 120 bushels, or three tuns of salt, according to the method now practised about Newcastle. And, allowing three chaldrons of coals to make a tun of salt, after the method there practised, agreeable to the estimates of some of their most experienced salt boilers; then nine chaldrons of coals (which at Newcastle are sold for 2 l. 9 s. 6 d.) would, by the method
here

here proposed make from brine 801 bushels or twenty tuns of salt. So that the expence of coals (where they can be had so cheap as at Newcastle) would not exceed 2s. 6d. for every tun of salt thus prepared. Although, in making white salt after the common methods, fuel is the most expensive article; and at Newcastle, where coals are so cheap, costs above half the price of the salt prepared with it.

THE same calculations also shew the extraordinary advantages of making white salt from natural brine, or rock salt in large pans, according to the method here proposed.

BUT if sea water be boiled down to white salt without any previous preparation, after the method before proposed; then, in a large square pan, such as is directed for that use, 65828 gallons of water will be evaporated at each process, from which may be obtained 235 bushels of salt, allowing a pound of salt to be extracted from forty pints of the water.

I AM very far from imposing the above calculations upon the public for such as will be found exactly true in practice; being sensible that true estimates of the expence of

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preparing white salt by the methods here proposed, can only be made from proper experiments. Although these calculations sufficiently prove, that a strong white salt may be made by the proposed methods considerably cheaper, than a weaker salt is made by the methods now in use ; and very probably might be afforded for half the price for which white salt is now usually sold.

IF this should be found true by experience ; then, as it would probably cost little more to refine the white salt than to make it from brine or sea water ; white salt refined after the method before directed might therefore probably be afforded for the same price now usually paid for common white salt, viz. from six pence to ten pence per bushel.

BUT as it may be necessary to set this matter in a clearer light ; let it be supposed that the white salt used in refining, costs eight pence per bushel, which is about the wholesale price of the salt made at Shields. In this eight pence is therefore included the price of coals, labour, a proper consideration for the houses, vessels, and other utensils employed in preparing this bushel of salt ;

salt ; and also the profit of the owner of the work. But as it is found by experience, that forty pounds of sea water is commonly evaporated for each pound of salt obtained, therefore in making a bushel or fifty-six pounds of salt $56 \times 40 = 2240$ pounds, or about 280 gallons of water may be supposed to be evaporated. But 280 gallons of water will very well dissolve twelve bushels of salt, allowing less than two pounds and an half of salt to a gallon of water. So that twelve bushels of salt may be refined, by evaporating the same quantity of water that is commonly evaporated in boiling one bushel of salt from sea water. And if a proper apparatus be used, such as before described, the expence of evaporating this quantity of water from the refined salt, will not probably exceed the expence of evaporating it from the boiled salt, according to the present method. But allowing the expence of evaporating the said quantity of water from the refined salt, to be treble the expence of evaporating it from the common boiled salt ; allowing also the dross and impurities of the boiled salt, together with that which is lost of it in refining, to be a twelfth part of the whole ; so that from twelve bushels of

the common boiled salt, only eleven bushels of refined salt can be obtained; then the price of eleven bushels of refined salt will be as follows:

	l.	s.	d.
To twelve bushels of common white salt at 8d. per bushel	0	8	0
To the expence of evaporating 280 gallons of water, and other expences of refining the said salt; being treble the expences of evaporating the same quantity of water, and of the other expences attending the preparation of a bushel of white sea salt, after the common method	0	2	0
<hr/>			
So that 11 bushels of refined salt will cost	0	10	0

Which is nearly eleven pence per bushel, and the expence of refining will be somewhat less than three pence per bushel.

BUT if, instead of sea salt, boiled rock salt, or brine salt be used, which can now be afforded in Cheshire for six pence per bushel; then the estimate will stand thus:

To

WHITE SALT.

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	l.	s.	d.
To 12 bushels of boiled rock, or brine salt	0	6	0
Charges of refining	0	2	0
<hr/>			
And the price of eleven bushels of refined salt will be	0	8	0
Which is $8d. \frac{8}{11}$, or nearly $8d. \frac{3}{4}$ per bushel.			

BUT if white salt prepared by the method recommended under proposition the first be used, which in several parts of Great Britain may probably be afforded for four pence per bushel; then, according to the above estimates, the refined salt will cost the refiner about six pence halfpenny per bushel, who may therefore very well afford to sell it for eight pence per bushel.

THE following estimate brings the matter a little nearer to practice, and therefore to some may seem more clear and satisfactory than the foregoing.

THE Dutch salt pan of a cylindrical form, forty feet in diameter, and eighteen inches deep, will contain 14106 gallons, wine measure. Supposing therefore, that into a pan of that size 14000 gallons of brine be poured, of such a strength, that from each gal-
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lon two pounds and an half averdupoize of falt may be extracted. From the whole 14000 gallons of brine, then may be extracted 35000 pounds or 625 bushels of falt. So that 625 bushels of refined falt may easily be prepared in such a pan in six days (the Dutch perform this operation in three days) allowing only three inches depth of water to exhale every twenty-four hours. And if the whole process be considered, the labour and attendance required in working such a pan will not appear greater, than is required in working a common Newcastle pan, in boiling sea water into falt. And, as very strong fires are used in boiling sea water, as many coals will probably be consumed in keeping such a common pan constantly at work, as in keeping the brine in the large Dutch pan of a mild and temperate heat. It therefore seems highly probable, that the expence of fuel and labour will be as great in working a common pan in boiling sea falt, as in working a pan of the above dimensions in refining falt.

BUT in a common pan about 120 bushels of falt may be boiled from sea water in six days, the price of which at eight pence per bushel is four pounds; in which four pounds

pounds is not only included the price of labour and coals, but also a proper allowance for the wear of vessels and utensils, and for all other contingent expences, together with the profit of the owner of the work. But supposing the expence of labour and fires only, in the proposed work for refining salt, to amount in six days to four pounds; and allowing three pounds more for the wear of vessels and utensils, and other contingent expences, and the refiners profit; and also eighteen shillings more for fifty-four bushels of white salt, which may be supposed to be wasted in the process. Then the whole expence of the work for six days (the profit of the owner included) will amount to seven pounds eighteen shillings; which being charged upon 625 bushels of salt, in that time refined, amounts to very little more than three pence per bushel.

As in the above calculations large allowances are made in every article; it therefore seems probable, that salt refined in the foregoing manner, may in several parts of Great Britain be afforded for so small a price as eight pence per bushel. But should we even suppose the unrefined white salt to

cost eight pence per bushel ; and instead of three pence per bushel, the price of refining as before estimated, should allow thrice that sum; or nine pence per bushel for refining it ; then the price of a bushel of this refined, salt would be seventeen pence, which is less than the Dutch pay for their strong refined salt ; and is less than half the sum now usually paid in London for bay salt, for curing provisions. For in times of peace, the best bay salt commonly there costs the consumer about ten shillings per bushel, weighing eighty-six pounds ; and now, in time of war, eleven shillings per bushel ; which, abstracted from the duty, is two shillings and ten pence two thirds for fifty-six pounds ; the weight of a bushel of white salt. So that if the British refiner can afford his salt at the market for less than two shillings and ten pence two thirds per bushel, large sums of money may be saved in the nation, which are now paid for foreign salt, and serve to enrich our enemies and rivals in trade.

ALL these calculations are made without any regard had to the salt duties ; upon a supposition that the salt is sold duty free, as that is which is exported abroad, or used in curing fish for foreign consumption. But
if

if the duties, as now regulated by law, are also taken into consideration, the British refiner of white salt, hath greatly the advantage over the importer of foreign salt, as will appear from the accounts already given of the duties upon each.

FROM all the above-mentioned facts and reasonings we may therefore conclude, that white salt refined after the foregoing method, (probably better in quality, and fitter for the use of the fisheries, and for curing all kinds of provisions, than French, and other impure kinds of bay salt) might easily be prepared in Great Britain, in any quantity wanted, and might be there afforded considerably cheaper than foreign bay salt; so that the money paid to foreigners for salt might easily be saved in the kingdom, and great advantages might arise from using this salt (or pure bay salt prepared as before directed) in the British fisheries; and by means thereof, the British colonies in the West Indies, and the navies and commerce of Great Britain, might be put out of a state of dependance upon its enemies for one of those necessaries without which they cannot possibly subsist.

AND now it may be proper to conclude this treatise with observing, that most of the facts referred to in the course of these disquisitions, are such, as the constant practice of those who make salt sufficiently warrants us to rely upon for true and certain ; or else, they are the observations of judicious salt officers, daily conversant in these matters ; or, of curious and inquisitive navigators, merchants, travellers, and naturalists ; or lastly, the experiments of many learned physicians, chemists, and philosophers ; the truth of which several facts, though many of them have long been published, hath never to my knowledge been called in question. So that these observations and experiments may probably be more relied upon by the public, than if they had only been made by myself ; since they have the testimony of many skilful and unprejudiced persons, who could have no notion of the uses to which they have been here applied. If therefore the arguments founded upon those facts should be esteemed any ways reasonable and satisfactory, I humbly presume to remark, that it might not be unworthy the wisdom of the British legislature to direct a more full inquiry to be made into a matter of this importance ;

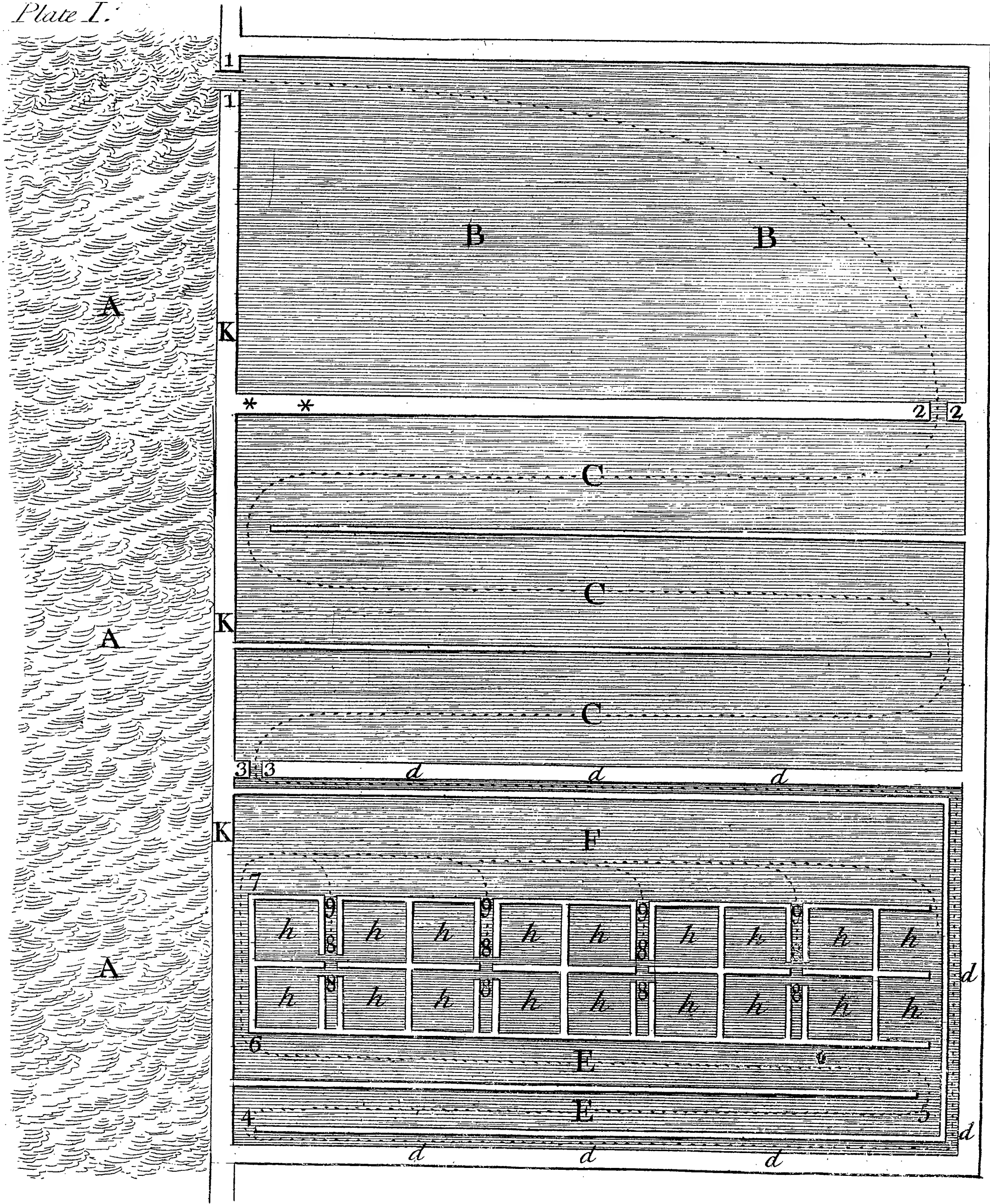
portance ; and to order proper works to be erected for making bay salt, and for making and refining white salt ; and to put those works under the management of able and judicious persons, to make exact and accurate tryals, in order to discover the best and cheapest methods of making bay salt, and of making and refining all kinds of white salt. And the methods which should be most approved of, might for the general good, be made public, and established by law, as a common standard, to which all those who make salt in the British dominions should be obliged to conform. And it would be the interest of the proprietors of salt works strictly to comply with the rules so established ; but if they should neglect them, the exact observance of them might, with the greatest ease be enforced ; since his Majesty hath officers who constantly attend at all salt works, who are commonly well skilled in the business of making salt, and might easily be made acquainted with the rules established, and with the qualities required in the several kinds of salt, and might have orders to inspect over the preparation of salt, and to receive none into the king's warehouses, but such as was fit for

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sale,

sale, and duly prepared according to the statute ; and might have power to seize, and (with the aid of the civil magistrate) to condemn and destroy all salt not rightly prepared, or at least to take care, that it was only applied to the improvement of land, and such like purposes. Such an establishment would put it out of the power of any one to impose bad salt upon the publick, as is now too frequently done, in a most scandalous manner, to the great damage of those who use such bad salt for curing provisions, and to the great prejudice of the health of many of his Majesty's subjects, who are often obliged to live upon provisions thus sadly cured. By such an establishment also, the salt officers might be made to do a very considerable benefit to the nation, with little additional trouble to themselves, and his majesty's subjects would have reason to esteem the duties upon salt less burthensome than at present, if by this means they were assured of being constantly supplied with such salt as was most fit and proper for the several purposes for which it was designed.

Plate I.



Explanation of the Plates.

P L A T E I.

A A A. Is the sea.

1 1. The entry, by which the sea-water passes into B B.

B B. The first receptacle ; in which the water is kept twenty inches deep.

C C C. The second receptacle, where the water maketh three turnings, as you see, and is ten inches deep.

* * The place, where the communication between the first and second receptacle is made in the French salt marsh, but here more conveniently removed to 2 2.

2 2. The opening, by which the first and second receptacle have communication one with another.

E E F. The third receptacle, which is properly called the Marsh.

d d d d d. Is a channel very narrow, through which the water must pass before it enters out of the second receptacle into the third.

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3 3. Is the opening, by which the water runs out of the second into the third receptacle.

The pricks, you see in the water throughout the whole scheme, mark the course and turnings, which the water is forced to make before it comes to *bbbb*, which are the places where the salt is made.

bbbb. Are the beds of the marish, where the salt is made; and in them the water must not be above an inch and an half deep. Each of these beds is fifteen feet long and fourteen feet large.

9999. Are the little channels between the beds.

8888. Are the apertures, by which the beds receive the sea-water after many windings and turnings.

PLATE

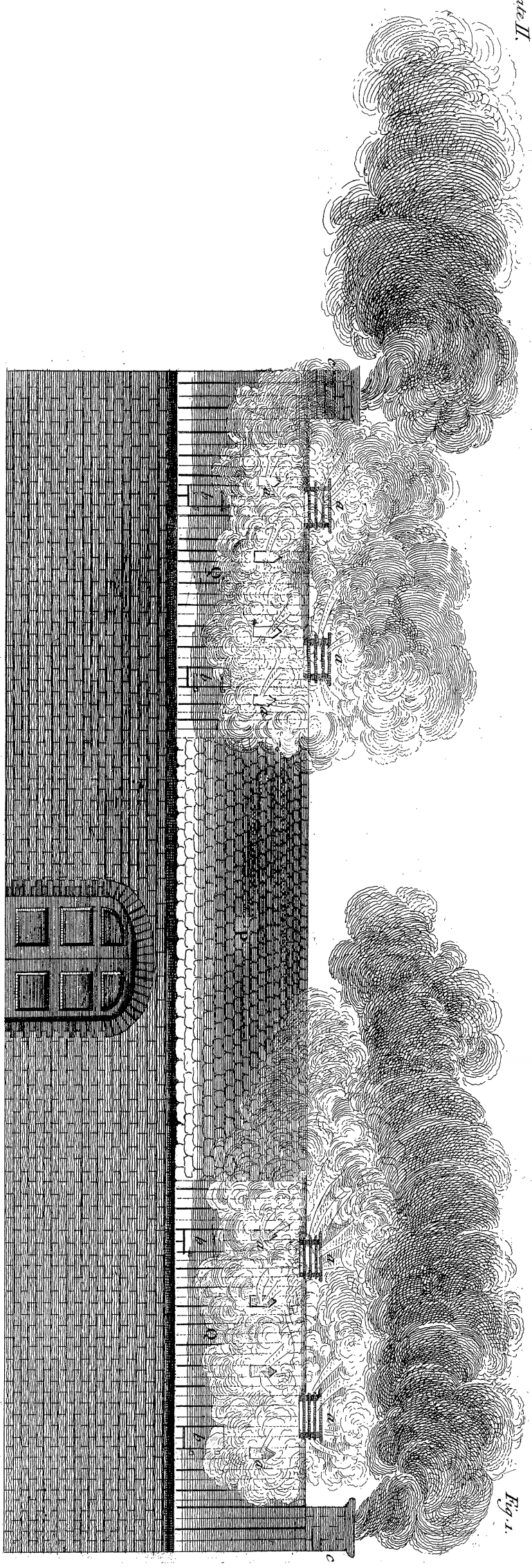


Fig. 1.

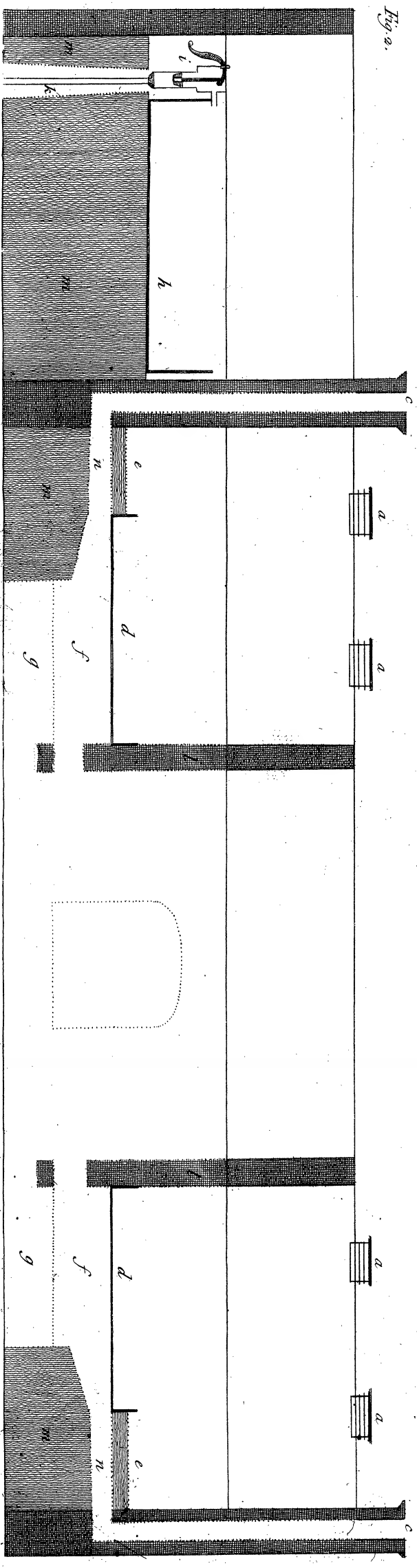


Fig. 2.

P L A T E II.

Fig. I. Being a representation of a marine faltern, with two boiling houses, and the forehouse in the middle between them.

a a a. L'oeuvres for the vapours which arise from the salt pan.

b b. Windows in the roof.

c c. Chimnies for the smoke of the furnaces.

P. Roof of tile or slate over the forehouse.

Q Q. Roofs of boards over the boiling houses.

Fig. II. A section of the said faltern made lengthways; together with a section of a shed placed at the end of it with a cistern for the sea-water.

a a. L'oeuvres at the top of the boiling houses for the steam.

c c. The chimnies.

d d. The salt pans.

e e. Walks at the end of each salt pan.

f f. The furnaces under the salt pans.

g g. The ash pits.

h h. The wood cistern for the salt-water, which is from it conveyed through pipes into the salt pans.

j. The pump, by which the salt water is raised into the cistern, from

U 4

k. The

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k. The well, sunk considerably deeper than the bottom of the saltern to the level of the sea at half flood.

ll. The partition walls between the forehouse and the boiling houses.

mm. Solid beds of earth.

n. The flues of the furnaces.

N. B. The pricked lines in the middle of the forehouse shew the situation of the door, from which there is a descent by an inclined plane to the bottom of the saltern.

PLATE

Fig. 1.

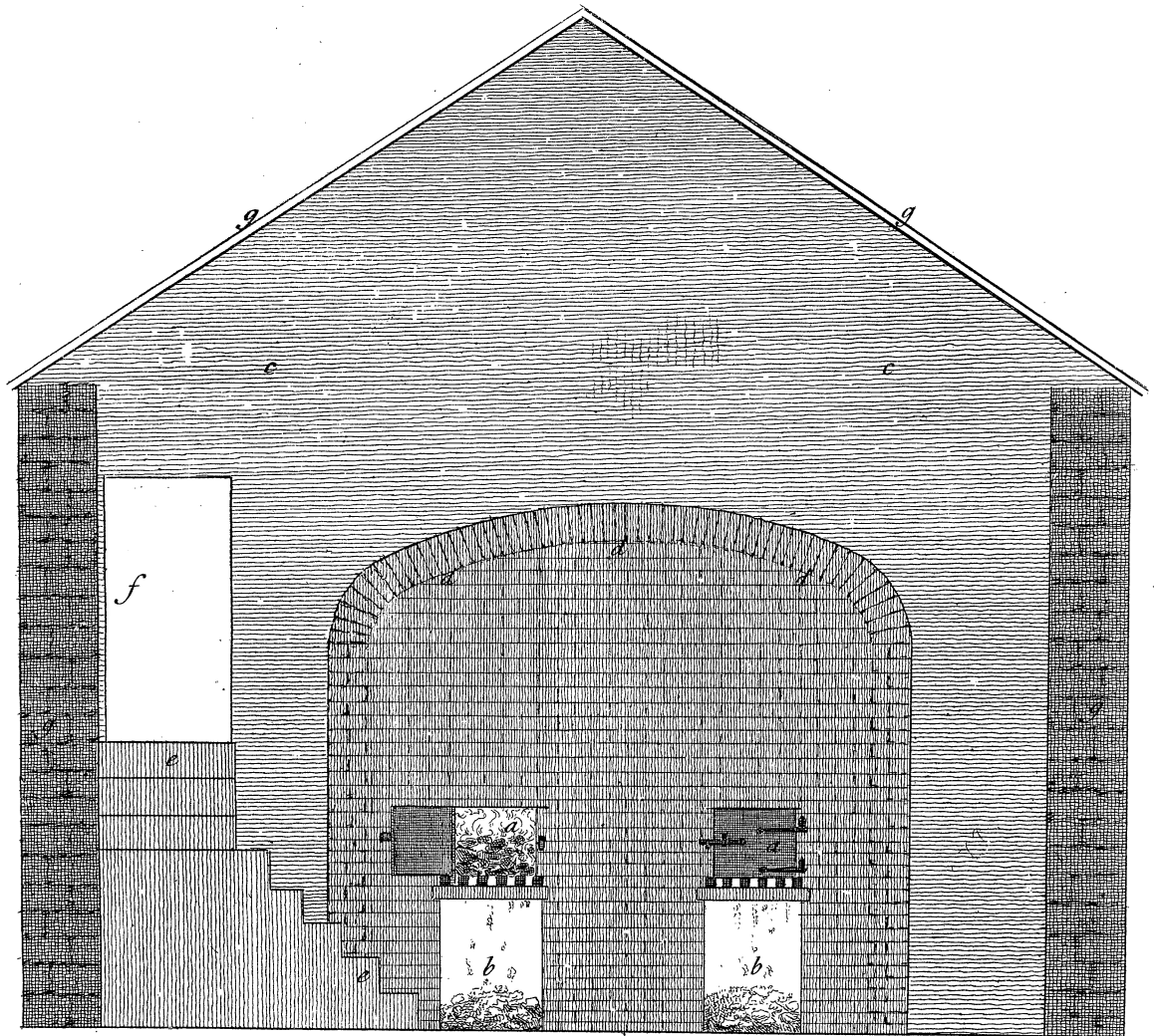
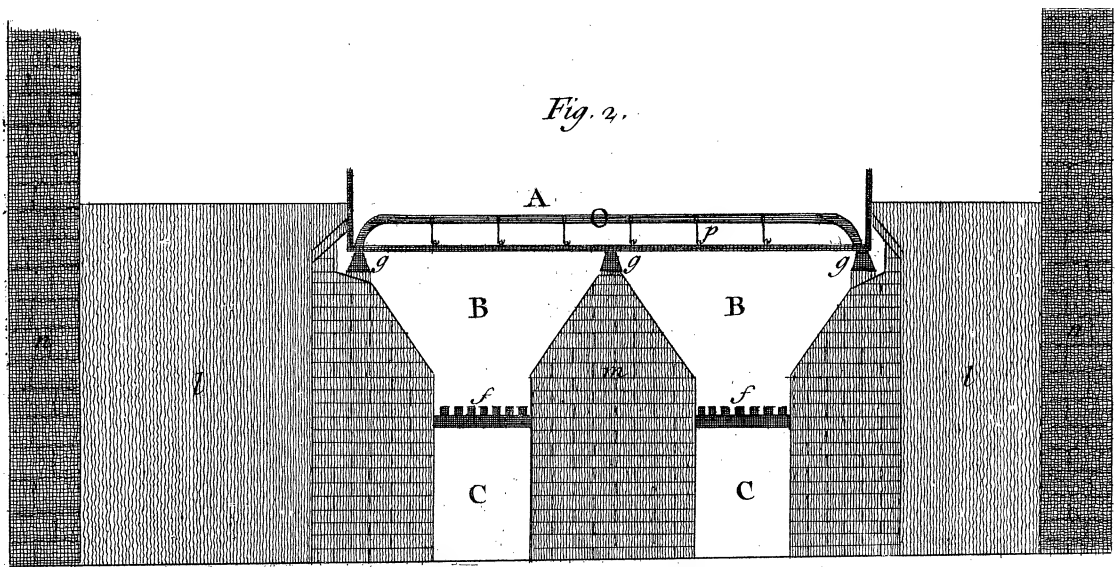


Fig. 2.



P L A T E I I I .

Fig. I. A cross section of the marine saltern exhibiting the front of the furnace.

a a. The doors of the two chambers of the furnace.

b b. The ash pits.

c c. The partition wall dividing the fore-house from the boiling house.

d d d. A brick arch which supports the partition wall when it is necessary to take away the lower part and repair the furnace.

e e. Stairs leading to the boiling house.

f. Door of the boiling house.

g g. Out walls and roof of the building.

Fig. II. A cross section of the furnace and salt pan.

A. The salt pan.

O. A cross beam of iron which serves to support the bottom of the pan by means of clasps and hooks.

B B. The two chambers of the furnace.

C C. The ash pits.

M. The mid-feather, dividing the body of the furnace into two chambers.

ff. The grates in which are seen the long bars of iron, and below them the cross bars

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bars or bearers, by which the others are supported.

g g. Pillars of cast iron called taplins which support the salt pan.

jj. Walks on the sides of the pan, that on the side next the door to which they draw the salt being broader than the walk on the other side.

ll. Beds of solid earth.

nn. The out walls of the saltern.

PLATE

Fig. 1.

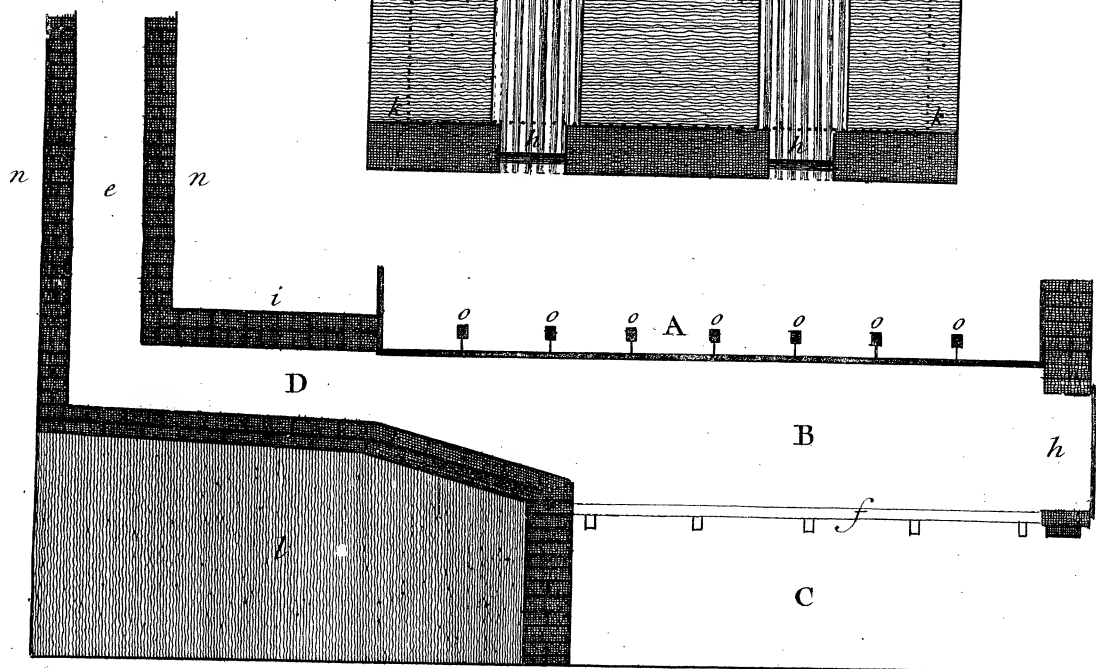
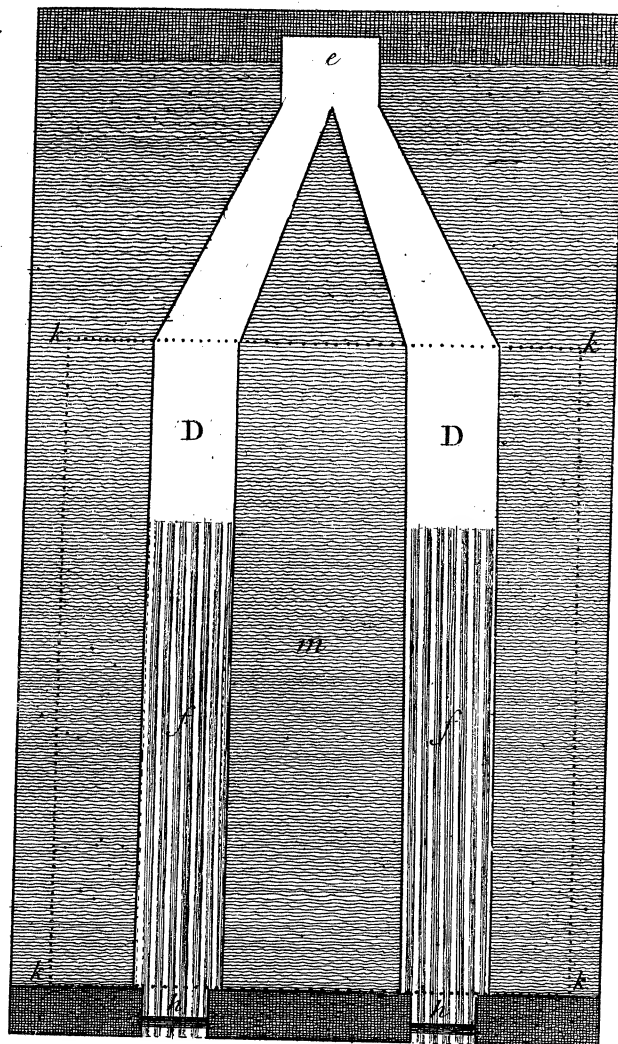
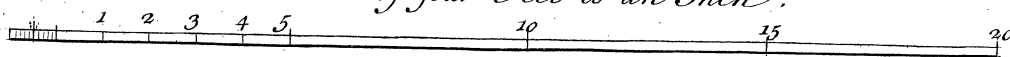


Fig. 2.

A Scale of four Feet to an Inch.



P L A T E IV.

Fig. I. A plan of the bottom of the furnace with the grates, flues, &c.

ff. The grates as in the preceding figure.

DD. The flues from which the smoke passes into the chimney.

e. The entrance into the chimney.

bb. The two mouths of the furnace.

m. The mid-feather.

kkkk. These pricked lines shew the dimensions of the bottom of the salt pan.

Fig. II. A section of the furnace made length ways.

N. B. The letters shew the same parts of the work as in the preceding sections. viz.

A. The salt pan.

oo. The iron beams which support its bottom.

B. A chamber of the furnace.

C. One of the ash pits.

D. One of the flues.

e. The chimney.

f. The grate.

b. A mouth of the furnace with

k. Its door.

j. Walk at the end of the salt pan.

l. Bed of solid earth.

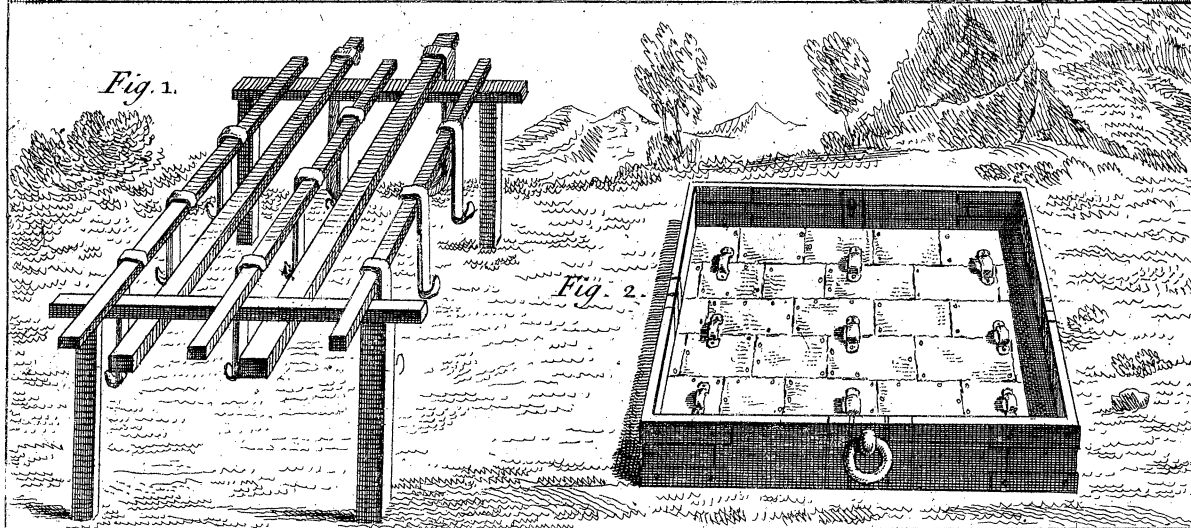
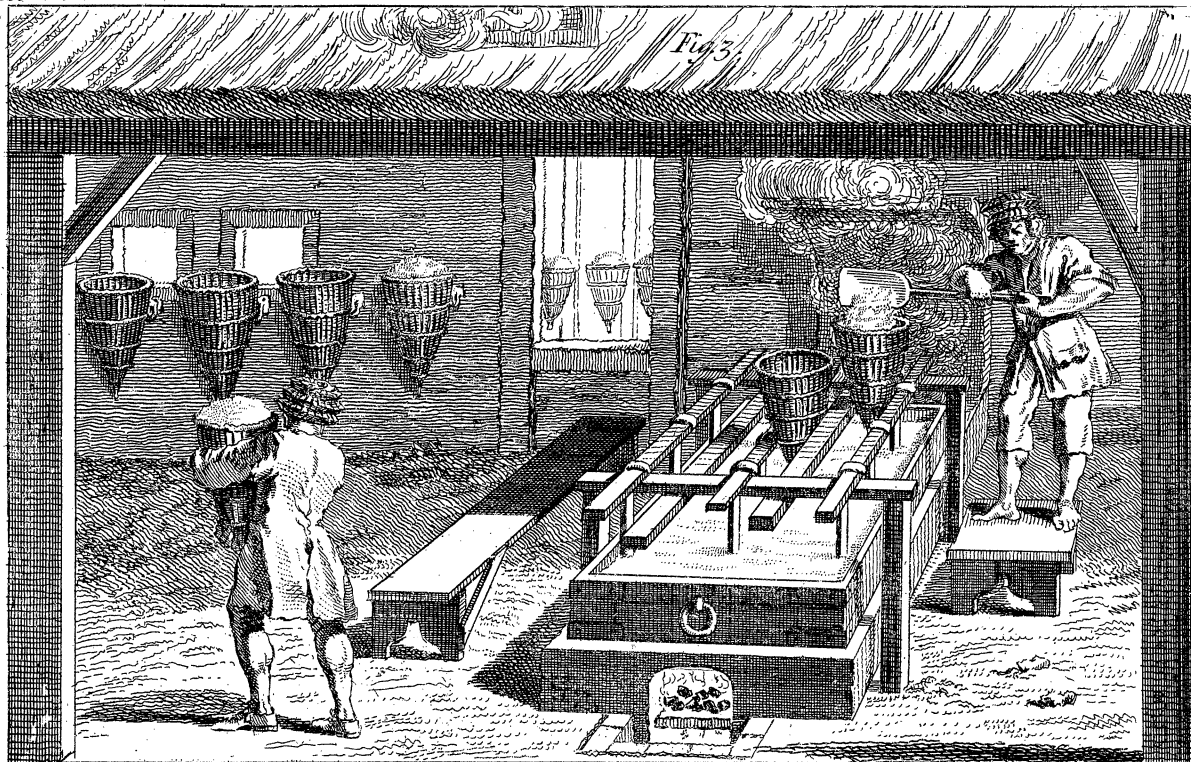
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922

Explanation of the Plates.

n n. The partition wall and walls of the chimney.

N. B. The figures in this and the foregoing plate are all made by one scale, which is given at the bottom of this plate.

PLATE



P L A T E V.

From Agricola, *De re metallica*, Lib. xii.

Fig. I. Four posts of wood fixed perpendicular in the earth ; on which are erected two end beams, and several cross beams, from which hang down hooks, supporting the bottom of the salt pan when fixed thereto by clasps. These are still used in Germany ; as they were lately at several salterns in England.

Fig. II. A salt pan of iron plates with clasps fixed to its bottom.

Fig. III. The same salt-pan placed over the furnace, and supported by the wood beams, with the operators taking out the salt into baskets, which in this work are hung up against the wall.

N. B. In these works there seems to have been no wall between the forehouse and boiling house ; and the salt pan seems to have been exposed to the dust and smoke of the furnace ; so that when they used straw for fuel, its light ashes flying about made the salt black.

P L A T E VI.

Fig. I. The falt pans formerly used in Cheshire four to a furnace ; together with their furnace, and the hot house or stove behind them. From the Acts of the Royal Society. In which,

a a a a. The hothouse between the wall and the chimney.

b b. Two tunnels.

C C. The chimney back into which the tunnels convey the smoke.

d d d d. The four pans.

E. The partition wall between the pans and the hot-house.

f f. The fire-places.

g g. The ash-holes.

h. The hearth below.

i. The descent to the hearth.

Fig 2. Two wicker baskets or barrows filled with falt and placed over the leach trough, as practised at the Cheshire falt works ; From the said acts.

Fig: 3. A skimmer made of boards, more commodious than the Cheshire loot, or any other instrument yet invented for skimming the brine.

Fig. 4. The Dutch wooden rake, its handle

Fig. 4.

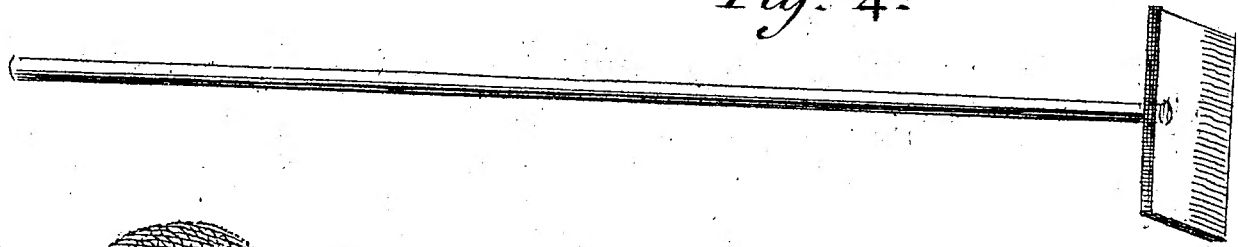


Fig. 5.

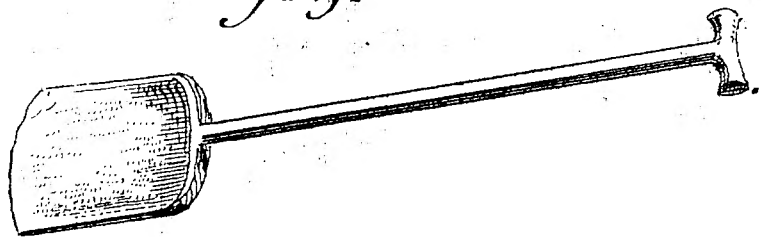


Fig. 3.

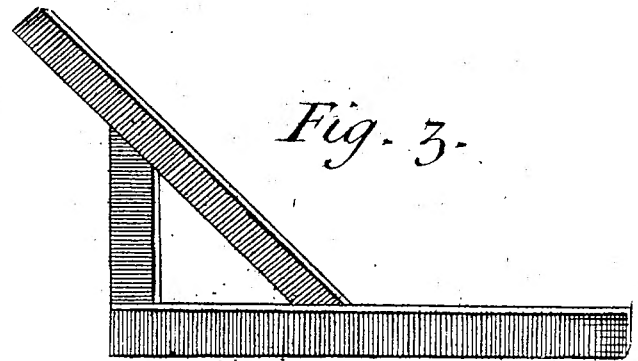


Fig. 2.

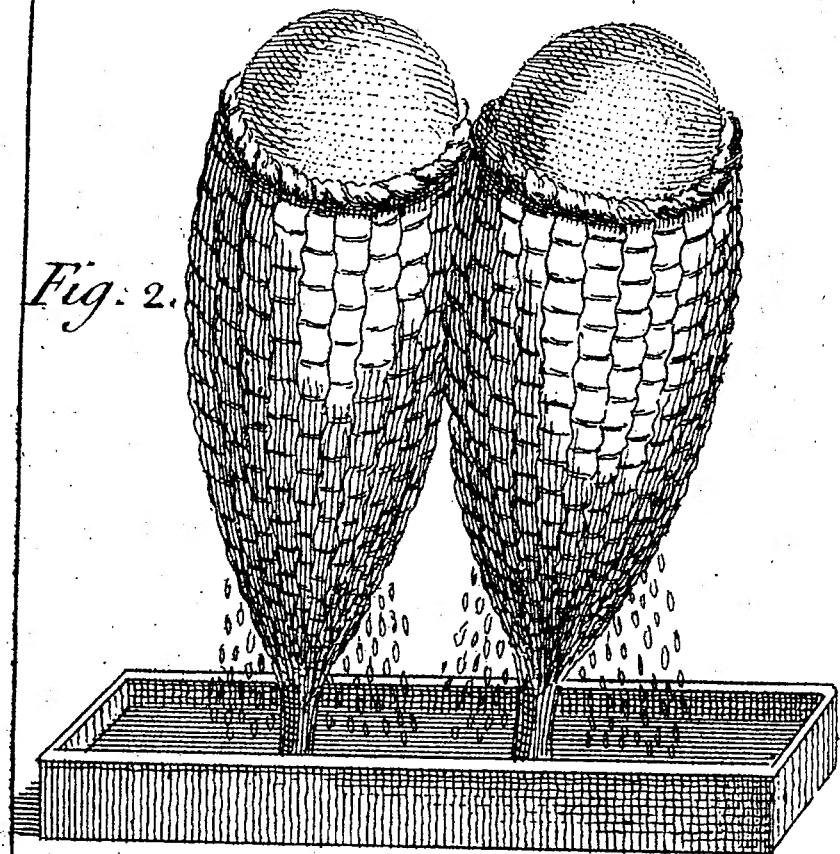


Fig. 6.

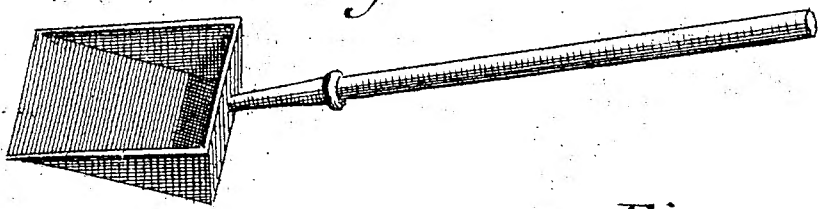
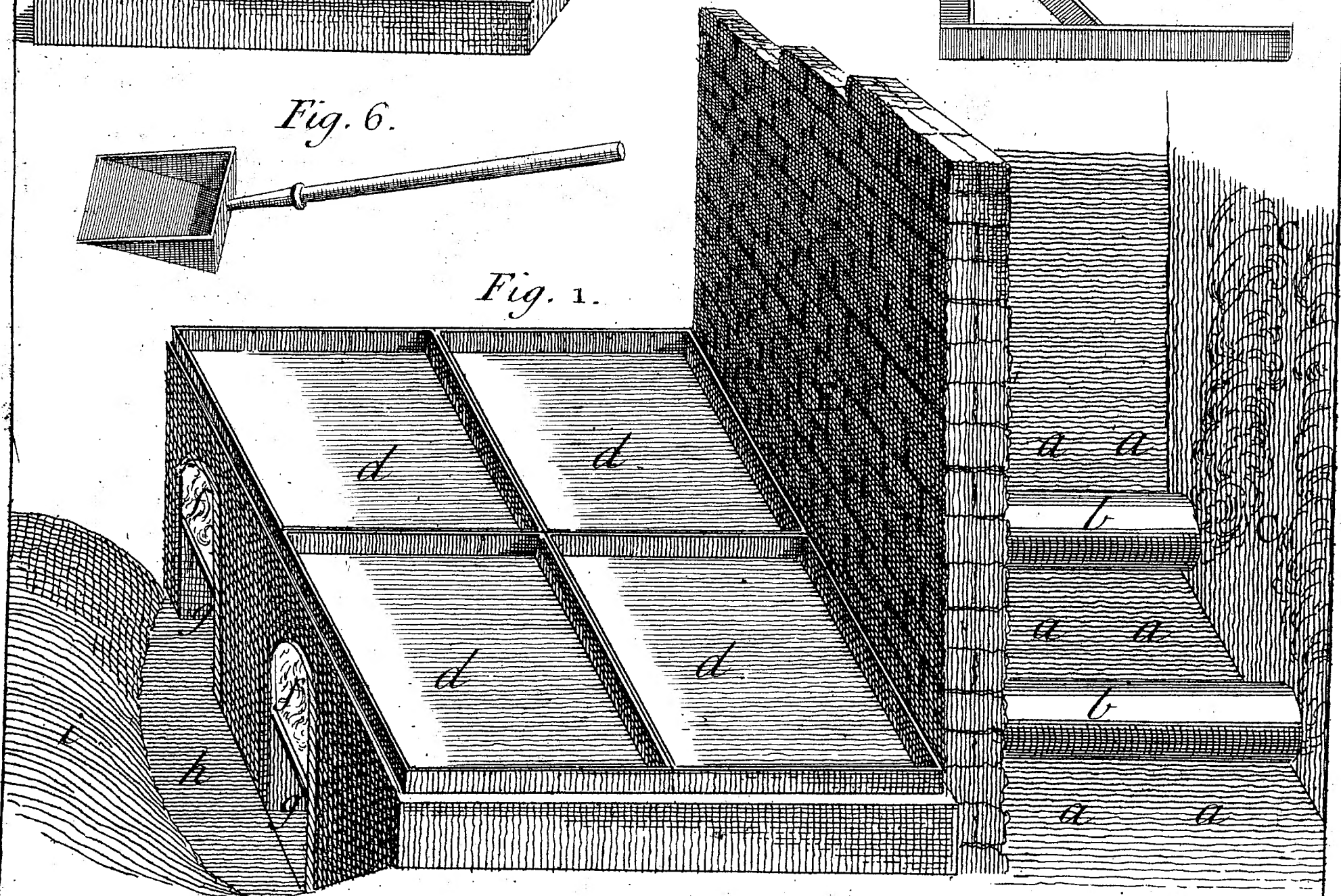


Fig. 1.



dle twenty feet long, being preferable to the iron rakes commonly used for drawing the salt, as they are apt to contract rust.

Fig. 5. A wood shovel, to take the salt out of the pan after it is drawn to one side with the rake.

Fig. 6. An iron ladle to take out the bittern.

F I N I S.

